Polygyny and Poverty

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Abstract

Countries where polygyny (one man married to several wives) is allowed differ from monogamous countries in several demographic characteristics: Women marry extremely early, the age-gap between husbands and wives is large, fertility is high, and typically a brideprice is paid at marriage. In monogamous countries, on the other hand, parents traditionally gave a dowry (negative brideprice) to their daughters at marriage. Polygynous countries are also on average poorer than monogamous countries. This paper analyzes whether the marriage system can account for these observations. I present an overlapping generations model with a marriage market and endogenous fertility. Two different marriage systems are analyzed, one in which polygyny is allowed and one in which it is not (monogamy). I find that polygyny leads to higher fertility and age gaps than monogamy, and to a positive price for women, while the equilibrium brideprice under monogamy is negative. I also find that the capital-output ratio is lower under polygyny. The reason is that under polygyny investing in wives and selling children is an alternative investment strategy that crowds out investment in physical assets. To derive quantitative results, I calibrate the model to the average of polygynous countries. I find that banning polygyny decreases fertility by 40%, compared to a 30% difference in the data. The savings rate goes up by 30% and output per capita increases 150%, which is close to the observed empirical differences.

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1 Introduction

Africa is the poorest continent in the world. Between 1965 and 1990, Africa's real GDP has exhibited no growth, while 17 countries in Sub-Saharan Africa grew at negative rates. At the same time, population growth has been extremely high. Sub-Saharan Africa's population is growing at 2.4 percent annually, which is almost twice the world average. This is caused by high fertility rates. The average *total fertility rate*[1] in Sub-Saharan Africa was 5.2 in 2000, compared to only 3.2 in the Middle East and North Africa, 2.9 in East Asia and the Pacific, and 2.7 in Latin America and the Caribbean. In addition, investment rates are much lower than in other regions. Investment averages 10.9 % of GDP in Sub-Saharan Africa, compared to 17.2% in the Middle East and North Africa, 20.5% in East Asia and the Pacific, and 15.8% in Latin America and the Caribbean. This is qualitatively similar to what is found in growth regressions (Barro 1997): Investment is positively correlated with GDP per capita, while fertility is significantly negatively related to output per capita. These empirical observations are statements about correlations and not about causality, which leads to the following questions. Why do most Sub-Saharan African countries save so little? Through what channels does fertility affect output? And what determines fertility? In this paper, I look at differences in marriage systems as a basic determinant of both fertility and investment rates. In particular, I ask whether the high incidence of polygyny[2] in Sub-Saharan Africa plays a role in the lack of development in the region. I will show that one simple change (i.e. enforcing monogamy) can have significant effects on fertility, investment, and output simultaneously.

To assess the hypothesis that family structure affects aggregate variables such as output and capital stocks, I present an extensive empirical background in Section 2. I document which countries currently allow for polygynous marriages and what fraction of the population is engaged in this practice. I find that all but two of the countries with high levels of polygyny are in Sub-Saharan Africa. In these countries between 10 and 50 percent of the male population has multiple. Nevertheless almost all men do marry.

[1] Number of live births per woman.

[2] Polygyny is the state or practice of having more than one wife at one time. The term polygamy refers to both, a man having several wives (polygyny) or a woman having several husbands (polyandry).

This shows that the Sub-Saharan African marriage pattern is very different from the common perception that polygyny means multiple wives only for a very small wealthy minority, as is the case in some Arab countries. Indeed, the average numbers of wives per married men in the polygynous part of Sub-Saharan Africa is substantially above one, as high as 1.7 in some countries. I contrast aggregate variables for polygynous countries to a comparable group of monogamous countries. I find that women in polygynous countries marry on average 4.5 years earlier and have 2.2 children more than women in the monogamous group. The average age difference between husband and wife is 7 years, which is 3.5 years higher than in monogamous countries. In almost all countries with polygyny men pay a positive price for a wife; whereas giving dowries (i.e. paying a negative price for a woman) is a very common practice in monogamous countries. The macroeconomic differences are also striking; investment rates and capital-output ratios in monogamous countries are about twice as high as in polygynous ones, while per capita output is roughly two and a half times as high.

I construct and analyze a theoretical model that demonstrates how polygyny can affect fertility and aggregate output. The model economy is populated by overlapping generations of men and women. Agents live for 3 periods, as children and as young and old adults. Apart from age and sex, agents are homogeneous. Fertility is chosen by men. Child production requires two inputs, fertile wives and resources to feed the child. There is a market for wives in which fathers supply daughters, and in which adult men buy wives. A man can choose to marry either a wife of his own age or a wife that is a generation younger than him. There is a standard technology that uses capital and labor to produce a consumption good. The representative firm behaves competitively. Two different economies are analyzed, one in which a man is allowed to have several wives (polygyny) and one in which he is allowed to have only one (monogamy).

I find that, when allowed, polygyny occurs in equilibrium. It arises despite a balanced sex ratio precisely because the endogenous age gap adjusts: Marrying younger women in an environment where population size is growing makes polygyny possible. Under monogamy, on the other hand, there is no age gap in equilibrium. One key finding is a positive equilibrium brideprice under polygyny compared to a negative price under monogamy. The different equilibrium prices have a significant impact on fertility decisions. A positive price for daughters decreases the effective marginal cost of children, while a negative price increases the marginal cost. This also affects the incentives to save. Under polygyny, men face a trade-off between investing in physical assets or investing in wives. The return on wives are children, which provide a direct utility benefit and, under polygyny, also a monetary benefit in terms of the brideprice received for daughters. This alternative investment strategy partially crowds out investment in physical assets, leading to a lower capital-output ratio when polygyny is allowed.

The model is then calibrated to match the investment and fertility rates in polygynous countries. To quantitatively assess the importance of the channels discussed above, I compute the steady state for the model in which polygyny is banned, using the same parameters. The model can account for a substantial fraction of the differences observed in the data. The model predicts a differential of 2.1 surviving children per women, compared to 1.5 in the data. Further, the model predicts an increase in the savings rate from 14% to 19%, which is similar to the empirical magnitude. Higher capital stock and lower population growth causes output per capita to go up by 140%, which is very close to the observed difference of 150%.

It might be difficult to enforce a law that prescribes monogamy. I therefore analyze an alternative policy, in which a father is not allowed to make his daughter's marriage decision. Allowing women to receive the gains from marriage, means that the return on wives is significantly reduced for men. Thus, this policy also increases the incentives to invest in physical assets. Qualitatively I find that this policy increases both the savings rate and GDP per capita by roughly 40%, while the effects on fertility and the number of wives are small. Compared to enforcing monogamy, this second policy has hardly any effect on family structure.

This paper is related to two literatures. The first branch is the (primarily static) economic analysis of the marriage market pioneered by Becker (1973, 1974), while the second is the (dynamic) analysis of fertility and savings decisions, with Barro and Becker (1989) being the standard reference. In static models of the marriage market, imbalances in the sex ratio are the most important factor that determines the equilibrium brideprice. Bergstrom (1994) provides a simple model that links the existence of brideprices to polygyny and endogenizes fertility.[3] Some people argue that dowry payments are not related to the marriage market, but should rather be interpreted as bequests given to daughters at marriage (see Botticini and Siow (2003) and Edlund (2001)).[4] This inheritance interpretation, however, leaves open the question of why such early bequests are not also given in polygynous societies. Anderson (2003) analyzes the importance of caste as a determinant of dowry payments.

My paper introduces the ideas put forth in the marriage literature into a dynamic context and explicitly relates marriage and fertility decisions. This allows the analysis of feedback effects, for example, the impact that family structure has on fertility, which in turn affects supply and demand in the marriage market in the next period. The dynamic structure also permits the analysis of demographic variables like age gaps and population growth rates, which are inherently dynamic phenomena.[5] Incorporating these dynamic effects is important as they lead to results which are significantly different from the static literature. First, I find a determinate sign of the brideprice for a monogamous society with a sex ratio of one and homogenous men and women.[6] Secondly, I show that a one-to-one sex ratio in a homogenous society does not preclude the occurrence of polygyny. Finally, I find that steady state life-time utility for both men and women is higher when monogamy is prescribed by law, while Becker had argued that women are better off when polygyny is allowed. The reason for this difference is that in static models polygyny only affects bargaining between spouses, while in this model polygyny significantly reduces output through its negative effect on the capital stock.

More recently, some work has been done on analyzing the interaction of marriage norms and the economy. Edlund and Lagerloef (2002) compare love marriages with arranged marriages. The effect that positive brideprices (here a feature of arranged marriages) lower incentives to save is also present in their work. Lagerloef (2002) provides a theory that jointly explains the decrease in polygyny and the increase in living standards. The argument crucially depends on the assumption that polygyny is a privilege reserved for the rich elite. Guner (1999) uses an overlapping generations model which gener-

[3] Grossbard (1978) also links brideprices to polygyny, without providing a formal model.

[4] See also Brown (2002) and Zhang and Chan (1999) on this.

[5] Rao (1993) also stresses the importance of age gaps in his empirical study of dowries in India.

[6] Becker (1973) argued that indeterminacy would necessarily follow.

ates family structure and inheritance rules endogenously, while allowing for polygynous marriages. While each of these papers deals with a particular aspect of my analysis, no attempt has been made to analyze the interplay of polygyny, marriage payments, fertility, and savings.

This paper is structured as follows. Section 2 provides empirical evidence on the differences between polygynous and monogamous countries. Section 3 sets up the main model. The steady states under monogamy and polygyny are characterized in Section 4. Section 5 outlines the calibration and the quantitative results. Section 6 analyzes what would happen if daughters could make their own marriage decisions. Section 7 discusses some extensions to the model.

2 Empirical Background

In this paper, I argue that allowing polygyny has a significant impact on the economy. This section provides some background on polygyny and other demographic differences across countries.

When discussing polygyny, the countries that most people think of are middle-Eastern Islamic countries. But while marrying up to four wives is generally accepted in the Arab world,[7] in practice polygyny is limited to a very small subgroup of the population in these countries. In Iran, only 1% of married men have multiple wives, and in Jordan about 3.8% of married men live in a polygynous union. What is perhaps less well known is that many Sub-Saharan African countries have much more wide-spread polygyny, with up to 50% of the male population being in polygynous unions. It is this second group that is the focus of this paper. The Table in Appendix A summarizes some demographic data for all countries where at least 10 percent of the male population is in a polygynous union. The last column in the table gives the percentage of ever married men aged 45-49. Almost all men do marry in these countries. This is worth emphasizing because a common perception is that two wives for some men means no wives for equally many men. The data shows that this is not true. Since the sex ratios in most countries do not deviate much from one, one wonders how such a high incidence of polygyny is possible.

[7] According to the Qu'ran a man can have up to four wives if he has the means to support them.

The answer to this puzzle lies in the extremely high spousal age gaps coupled with high population growth (Tertilt 2003). Consider the simple example in which population doubles every generation and the age gap is an entire generation. Then it would be possible for *every* man to marry two wives. The table in Appendix A shows that the age gap at first marriage is almost 7 years in highly polygynous countries. Annual population growth in this area is 2.7 percent, which amounts to a 20% increase over 7 years. This would mean that on average each man could marry 1.2 wives, or put differently, 20% of the population could marry two wives. Note that as the average age gap takes only first marriages into account, the age gap with second wives has to be higher, which further increases the potential for polygyny.

Polygynous countries differ from monogamous ones along other demographic dimensions as well. One way to see this is to compute data averages for all polygynous countries and for all monogamous countries and to compare them. The problem with this simple comparison is that countries like the United States are monogamous but differ from Sub-Saharan Africa along many dimensions. Instead of comparing polygynous countries with *all* monogamous ones, one should rather contrast them to a more comparable group. Given my modelling assumptions, a natural criterion is to select only countries where fathers make the marriage decision for their daughters. However, lacking a good measure of this feature, I have explored several other criteria for selecting countries. Note that almost all highly polygynous countries are located close to the equator, To get a comparable group of monogamous countries, I therefore consider only those that have an absolute latitude of less than 20. There are about 60 monogamous countries fairly close to the equator, mainly in the Caribbean and the Pacific, parts of South America, and Africa, which I will simply call the monogamous group. Table 1 reports data for polygynous countries in column 1 and for the monogamous group in column 3. Alternatively, selecting monogamous countries based on income leads to very similar numbers (details available upon request). In addition, Table 1 includes averages for countries within Sub-Saharan Africa that have low levels of polygyny (column 2) and data on Western Europe and North America (column 4).

The data reveals striking demographic differences between polygynous and monogamous countries. The average age difference between husband and wife in highly polyg-

Table 1: Demographics

Number of countries	High polyg.# (see table 7) (20)	Other SSA (27)	Monogamous |Latitude| < 20 (62)	N. America W. Europe (21)
Fertility and Mortality				
Total fertility rate, 1980	6.73	6.24*	4.55	1.84
surviving 1 yr, 1980	5.47	5.09*	3.57	1.79
surviving 5 yrs, 1980	5.04	4.64*	3.56	1.76
annual pop. growth, 1960-85	2.7%	2.6%	2.1%	0.8%
Infant mortality rate, 1980	11.9	12.1	6.9	1.2
Child mortality rate, 1980	19.2	18.7	11.6	1.4
Demographics				
male age at marriage	25.8	26.6	26.9	29.3
female age at marriage	18.9	21.4***	23.4	26.8
age gap	6.9	5.09***	3.5	2.4
% women married by 19	40	21***	13	2
% population under 16, 1985	46	44*	38	20
Economic Variables				
$\frac{S}{Y}$ ♭	13.5	10.9	18.4	23.0
$\frac{I}{Y}$ avg, 1960-85 ♮	8.5	12.8**	15.9	26.2
$\frac{K}{Y}$, 1985	1.0	1.5**	1.9	3.0
GDP p.c.,1985	1,029	1,360	2,691	11,950

* significantly smaller/greater than pol. countries at 10% level, ** 5% level, *** 1% level

Data Sources: See Appendix A.1. ♭ at domestic prices, ♮ at international prices.

ynous countries is 7 years compared to only 3.5 for the monogamous group. Women in polygynous countries marry more than 4 years earlier on average compared to women in monogamous countries. Women in polygynous countries have more children than in monogamous ones. The total fertility rate in 1980 was 6.7 on average in polygynous countries compared to only 4.5 for monogamous countries. Demographers have pointed out the close link between infant and child mortality and fertility rates (Preston 1978).[8] One causal force typically given is that if many children die before adulthood, then parents need to produce more children to guarantee someone taking care of them in old age.[9] The table shows that infant mortality rates as well as child mortality rates are indeed lower in monogamous countries. To take mortality differences into account, I compute the number of surviving children. The table shows that mortality explains only part of the fertility differential across the two groups. There is a 2-child difference in the number of children surviving up to the age of one. Another way to control for differences in mortality is to compare high polygyny countries to the other countries in Sub-saharan Africa. Note that the average probabilities of dying before the first and the fifth birthday are almost identical in the two groups of African countries. Again, all measures of fertility are highest in the high polygyny region, for example the number of children born is roughly 10% higher in the highly polygynous group. Similarly, other demographic differences remain substantial: The average age gap for a married couple is only 5.1 years in the Sub-Saharan African control group, almost 2 years less than in the high polygyny group, while the proportion of women that marries before the age 19 is 50% lower in the low polygyny group. These last two differences reinforce the argument made above that women marrying substantially older men is an important component of widespread polygyny.

Sub-saharan African countries with a high degree of polygyny are the poorest countries in the world. Their per capita GDP is 25% lower than that of the other countries in the region, and only 40% of the GDP of monogamous countries located in the same latitude range. Table 1 also shows that investment rates and capital output ratios are lowest in polygynous countries. Compared to highly polygynous countries, investment rates are 50% higher in the rest of Sub-Saharan Africa and twice as high in the monogamous group. The investment output ratio provided is computed at international prices.

[8] Infant mortality is the percentage of live births that do not survive until age 1, while child mortality is the percentage of live births that die before the age 5.

[9] There is also the reverse force that lower fertility increases birth spacing which leads to lower child mortality. Despite a large amount of empirical research, the exact relationship between infant and child mortality and fertility, remains controversial (see for example Palloni and Rafalimanana (1999) and LeGrand and Phillips (1996)).

It is well-known that the relative price of investment goods is higher in poor than in rich countries. Thus, nominal savings rates (savings as a percentage of gross national product at national prices) are a better measure of savings for the purpose of this paper. The data shows still large differences in nominal savings rates. The average savings rate for monogamous countries was 18.4% between 1960 and 1985, compared to only 13.5% for the polygynous group.

2.1 Brideprice and Dowry

The argument put forth in this paper implies differences in the direction of marriage payments across countries. Grooms in polygynous countries, it is argued, pay a positive brideprice while in monogamous countries grooms receive a payment (a dowry). It is an obvious question whether we observe this pattern in the data. Unfortunately, data on marriage payments is scarce. In this section I argue that the available data is consistent with the implications of this paper.

In some cultures payments and gifts are made in both directions.[10] For the purpose of this paper, I call any net transfer coming from the groom or his family a (positive) brideprice and any net transfer from the bride's side a dowry (or negative brideprice).

Brideprices are most common today in African and Muslim countries. A typical brideprice in Africa consists of cattle. In many (non-African) Muslim countries, a brideprice consists of jewelry, money, gold, and/or land. Traditionally, brideprices were also common in China. A dowry often consists of household items, jewelry, and clothes, but can also be a house or land. Dowries were common in ancient Greece and Rome, and in Europe until the end of the 19th century. Europeans brought this tradition to North and South America during the 17th and 18th century. Today, dowries are very popular in South Asia.

For each of the countries with high levels of polygyny (see Appendix A), I have reviewed country studies written by anthropologists and ethnographers. My finding is that brideprices are the norm in polygynous countries, with the exception of Bangladesh that experienced a recent transition from brideprice to dowry payments.

[10] See Goody and Tambiah (1973) for a detailed description of marriage payments around the world.

Table 2: Polygyny and Brideprices

Polygyny/Monogamy	brideprice	dowry or no price
monogamous	37.5%	62.5%
less than 20 % pol.	52.8%	47.2%
more than 20% pol.	90.8%	9.2 %

Source: Hartung 1982

Historical evidence confirms this finding. Information on marriage traditions gathered by ethnographers has been systematically organized by Murdock (1986) in his Ethnographic Atlas, which contains roughly 1,000 societies. Hartung (1982) uses this data to study the correlation of marriage payments with polygyny (see Table 2). He finds that more than 90% of all societies with widespread polygyny (more than 20% of all married men) use brideprices and that two thirds of the monogamous societies do *not* use brideprices. Botticini and Siow (2003) report the use of marriage payments in past civilizations. Out of 6 civilizations classified as polygynous, 4 pay a positive price to acquire a bride. Out of the 9 monogamous civilizations for which data on marriage payments is available, 7 are reported to use dowries as the predominant marriage payment.[11]

While more and better data would be desirable, the evidence seems to suggest a high correlation between polygyny and the usage of brideprices, on the one hand, and between monogamy and the practice of dowry, on the other hand.

3 The Model

I consider an infinite-horizon, overlapping generations model. Agents live for 3 periods: as children, as young adults, and as old adults. Only adults make choices. Young adults are endowed with one unit of labor which they supply inelastically at wage w_t. Agents derive utility from consumption in both periods of their lives and from having children. Parents receive utility from the number of children and disutility from the number of

[11] Most civilizations use several types of payment simultaneously. The statement made here refers to the net payment (see the last column in Table 1 in Botticini and Siow (2003)).

unmarried daughters. There are men and women in this economy. In order to have children, agents need to be married.

Fertility is endogenous. For simplicity, I assume that only men choose the number of children. Other intra-family decision-making mechanisms are discussed in Section 7. Half the children are male, and half are female.[12] Let $g(f_t, n_t)$ be the cost of child-rearing as a function of male fertility in t, f_t, and the number of (fertile) wives, n_t.

Assumption 1 *$g(f, n)$ is strictly increasing in f, strictly decreasing in n, $g(f, n) > 0,\ \forall (f, n)$, and $lim_{n \to 0}\ g(f, n) = \infty$.*

Assumption 1 assures that children are never free, and that it is impossible to have children without a fertile wife. Moreover, more wives can produce the same number of children at a strictly lower cost.

I assume differential fecundity for men and women. All adult men (independent of their age) are fertile, while women are fertile only as young adults.[13]

There is a decentralized marriage market in which fathers sell their daughters and acquire brides. Brides can be of two ages: children (girls) or adults (women). Let $p_t^g \in \mathbb{R}$ denote the price of a girl at time t, and $p_t^w \in \mathbb{R}$ the price of a young adult woman. The potential buyers in the bride market are adult men of both ages. Since a man is fertile both when young and when old, he can have children in either (or both) periods of his adult life. Superscripts denote the age of a man, while subscripts refer to the type of wife. A young man can marry a girl, n_g^y, or an (adult) woman, n_w^y. He can also marry women when he is old, n_w^o.[14] The timing of births is also endogenous. A man can have children when young, f^y, or old, f^o. Fathers make their daughters' marriage decisions. Let d_g^y be the number of girls given into marriage by a young father, and d_g^o the number of girls given into marriage by an old father. Alternatively, daughters can stay with their parents for one period and then be given into marriage as young adults. Depending on when

[12] Edlund (1999) analyzes endogenous sex choice of children. Given that empirical sex ratios deviate no more than 8% from one this is of limited relevance for the questions addressed in this paper.

[13] Siow (1998) uses a similar assumption to analyze how differential fecundity affects gender roles in monogamous unions.

[14] It would never be optimal for an old man to marry a girl, since his wife would be fertile after the man's death. Thus it is without loss of generality to omit this option.

daughters were born, this would happen when fathers are old, d_w^o, or potentially after their death, d_w^d, where the superscript d stands for 'dead'. Then $d = d_g^y + d_w^o + d_y^o + d_w^d$ is the total number of married daughters.

3.1 Polygynous Society

In the polygynous society men are allowed to marry as many wives as they wish. To keep the model tractable, no integer restrictions are made on any of the variables.

Men

The choice variables for a man are consumption c, saving (investment in physical capital) s, the number of wives n, the number of children f, and how many daughters to sell d. Recall that the subscripts g and w refer to 'girls' and 'women', and denote the age of the bride at the time of the marriage, while the superscripts y, o and d stand for 'young', 'old' and 'dead', and corresponds to the age of the man. Suppressing time subscripts, the man's problem is:

$$\begin{aligned}
&\max_{c,s,n,f,d} \ln(c^y) + \beta \ln(c^o) + \gamma \ln(f^y + f^o) - v(\frac{f^y + f^o}{2} - d) \\
&s.t. \quad c^y + s^y + p_g n_g^y + p_w n_w^y + g(f^y, n_w^y) \leq w + p_g d_g^y \\
&\qquad c^o + s^o + p_w n_w^o + g(f^o, n_g^y + n_w^o) \leq (1 - \delta + r)s^y + p_g d_g^o + p_w d_w^o \\
&\qquad 0 \leq p_w d_w^d + (1 + r - \delta)s^o \\
&\qquad d_g^y + d_w^o \leq \frac{f^y}{2} \quad \text{and} \quad d_g^o + d_w^d \leq \frac{f^o}{2} \\
&\qquad c^y, c^o, s^y, s^o, f^y, f^o, n_g^y, n_w^y, n_w^o, d_g^y, d_g^o, d_w^o, d_w^d \geq 0.
\end{aligned} \tag{1}$$

where β is the discount factor, and γ captures how much a man cares about the number of children. The last term of the utility function is the disutility a man receives from having unmarried daughters.[15] The return on investment is standard, $1 + r - \delta$.

The first constraint is the budget constraint when young. The income during this period is the wage, w, and potentially the revenues from selling daughters, $p^g d_g^y$. Expenditures are for consumption, the purchase of wives, and the cost of raising children

[15]Including unmarried sons in the utility function would not change any of the results since sons never remain unmarried in equilibrium.

during this period, $g(f^y, n_w^y)$. The budget constraint for an old man looks similar except that he is not allowed to buy any girl-brides.[16] The third constraint is a budget constraint for after the man's death. This may seem odd, but note that the brideprice could be negative, in which case a man may want to set up a "trust fund," s^o, to ensure that his daughters can marry even after his death. The last two constraints simply say that a man cannot sell more daughters than the number of female children he has in the relevant period.

Women

Women have the same utility function as men. They receive utility from consumption, children, and married daughters. As men, women are endowed with one unit of labor when young adults and they need to save for retirement. One crucial difference between men and women is their fecundity: only young adult women bear children. A second important difference is that women are not allowed to marry more than one husband. Moreover, the marriage decision is taken by a woman's father. Finally, husbands make the fertility as well as marriage market decisions for their daughters. The only choices women make are consumption and savings decisions. These assumptions are made to keep the problem tractable, alternative ways of intra-family decision-making are discussed in Section 7. Women incur a cost of child-rearing. I assume that the cost of child-rearing incurred by all wives jointly is equal to the husband's payment.[17] Further, I assume that each of the wives incurs an equal share of this cost. Thus, the cost of child-rearing for a woman whose husband has a total of n wives and f children is $\frac{g(f,n)}{n}$. Unmarried women cannot have children. Then, the woman's problem, given her father's and husband's decisions (f, n, d), can be written as

$$\begin{aligned}
&\max_{c_f^y, c_f^o, s_f} \ln(c_f^y) + \beta \ln(c_f^o) + \gamma \ln(\frac{f}{n}) - v(\frac{f-d}{n}) \\
&s.t. \;\; c_f^y + s_f + \frac{g(f,n)}{n} \leq w \\
&\qquad c_f^o \leq (1 + r - \delta) s_f
\end{aligned} \tag{2}$$

[16]See footnote 14 on this.

[17]This could easily be generalized to any other cost sharing rule between spouses. The qualitative results would not be affected by this.

3.2 Monogamous Society

The monogamous society has the additional constraint that a man cannot marry more than one wife. Thus the man's problem is the same as (1) with the additional constraint: $n_g^y + n_w^y + n_w^o \leq 1$. The woman's problem is exactly the same as under polygyny.

3.3 Population Dynamics

Let M_t be the number of young adult men alive in period t, call this generation t. The number of men in $t+1$ is determined by the number of men in t and their fertility. Formally, the law of motion is $M_{t+1} = \frac{1}{2}[M_t f_t^y + M_{t-1} f_t^o]$. Later I will analyze balanced growth paths of this economy, i.e. equilibria where population and output grows at a constant rate and per capita variables are constant. Let $\eta = \frac{M_{t+1}}{M_t}$ denote the population growth factor. Then the law of motion can be written as

$$\eta^2 = \frac{1}{2}[\eta f^y + f^o] \tag{3}$$

3.4 Production

There is an aggregate technology that uses capital and labor to produce the consumption good. I assume a standard Cobb-Douglas production function, $Y_t = AK_t^{\alpha} L_t^{1-\alpha}$. The representative firm maximizes profits. Each young adult supplies one unit of labor inelastically, hence aggregate labor supply is $L_t = 2M_t$. In equilibrium, the capital stock used for production in $t+1$ is equal to aggregate savings in t. Men save when young and potentially when old (as a trust fund for their daughters' marriages) and women save when they are young. Hence, $K_{t+1} = (s^y + s_f)M_t + s^o M_{t-1}$. On the balanced growth path the capital-output ratio stays constant. Dividing by Y_t, the capital-output ratio can be written as

$$\frac{K}{Y} = \frac{1}{A} \left(\frac{s_f^* + s_y^* + \frac{s^{o^*}}{\eta^*}}{2\eta^*} \right)^{1-\alpha} . \tag{4}$$

This expression shows that differences in $\frac{K}{Y}$ between polygynous and monogamous countries can come through two different channels, differences in saving rates and differences in the population growth rate.

In standard models, the number of people is equal to the number of workers, which implies that output per capita is equal to output per worker. This is not true here, since both children and old people do not work. Therefore, the relationship between output per worker and output per capita depends on how fast the population is growing. On the balanced growth path, output per capita is

$$Y_{pc} = \frac{Y_t}{2M_t + 2M_{t-1} + 2M_{t-1}} = \frac{\frac{Y}{L}}{1 + \eta^* + \frac{1}{\eta^*}} \ ,$$

where output per worker is equal to $\frac{Y}{L} = A^{\frac{1}{1-\alpha}} (\frac{K}{Y})^{\frac{\alpha}{1-\alpha}}$. This shows that faster growing populations have lower output per capita, holding all else equal.

3.5 Definition of Equilibrium

There are two marriage markets that have to clear. A market for female children and a market for adult women. Girls are demanded only by young adult men, hence the total demand is $n_g^y M_t$. The supply might come from young or old fathers, yielding a total supply of $d_g^y M_t + d_g^o M_{t-1}$. Therefore, market clearing for girls is $n_g^y M_t = d_g^y M_t + d_g^o M_{t-1}$. On the balanced growth path, this can be written as

$$n_g^y \eta = d_g^y \eta + d_g^o \quad . \tag{5}$$

Fathers who had daughters when they were young and fathers who had daughters when they were old may both supply adult daughters. The total supply of adult brides in t is $d_w^o M_{t-1} + d_w^d M_{t-2}$. Both young and old men may demand adult brides. Thus, market clearing period t is $d_w^o M_{t-1} + d_w^d M_{t-2} = n_w^y M_t + n_w^o M_{t-1}$. On the balanced growth simplifies to

$$d_w^o \eta + d_w^d = n_w^y \eta^2 + n_w^o \eta \quad . \tag{6}$$

As mentioned before, I analyzed balanced growth paths of this economy. Moreover, since agents in this model are homogenous (except for age and sex), I focus on symmetric equilibria where all agents of a given age and sex receive the same allocation.[18]

Definition 1 *A symmetric balanced growth path for the economy where polygyny is allowed is an allocation: consumption* (c^y, c^o, c^y, c_f^o)*, savings* (s^y, s^o, s_f)*, number of wives*

[18] I conjecture that no asymmetric steady states exist and that the qualifier symmetric is redundant.

(n_w^y, n_w^y, n_w^o), *numbers of children* (f^y, f^o), *and numbers of daughters sold* $(d_g^y, d_g^o, d_w^o, d_w^d)$, *prices* (p^g, p^w, r, w), *a population growth factor* η *and a capital-output ratio* $\frac{K}{Y}$ *such that*

- *Given prices,* (c, s, n, f, d) *solves the man's problem (1).*
- *Taking prices and* (f, n, d) *as given,* (c_f, s_f) *solves the woman's problem (2).*
- *Population dynamics evolves according to (3).*
- $\frac{K}{Y}$ *is given by (4).*
- *Markets for girls and adult women clear (conditions (5) and (6) hold).*
- *Profit maximization:* $r = \frac{\alpha}{\frac{K}{Y}}$ *and* $w = (1-\alpha)A^{\frac{1}{1-\alpha}} \frac{K}{Y}^{\frac{\alpha}{1-\alpha}}$

The symmetric balanced growth path for the economy where polygyny is banned is defined in the same way with the only modification that the man's problem has the additional constraint of marrying at most one wife.

4 Characterizing the Balanced Growth Path

Whether polygyny is allowed matters both qualitatively and quantitatively. In this section, I characterize the symmetric BGP under polygyny and monogamy. Existence is discussed in Appendices B.1 and B.2. Analytical results can be derived for the sign of the brideprice, the demographic structure, and the relationship between population growth, fertility, and the average number of wives. Since the entire model cannot be solved analytically, I will present numerical results in Section 5.[19]

4.1 Polygyny

Note that the price of a bride has to be positive in a polygynous society since otherwise each man would want an infinite number of wives, which cannot be an equilibrium. This insight together with some other characteristics of the polygynous BGP is summarized in the following proposition.

[19]The equation determining the equilibrium brideprice under monogamy is a highly non-linear function, while under polygyny, equilibrium fertility is the solution of a polynomial equation of degree 4.

Proposition 1 *If polygyny is allowed, then on any balanced growth path equilibrium:*

1. *The brideprice is always strictly positive:* $p_t^g > 0$ *and* $p_t^w > 0$.
2. *There is an age gap between husband and wife* ($n_w^y = 0$).
3. *Men marry when young* ($n_w^o = 0$).
4. *Men have children when old* ($f^y = 0, f^o > 0$).
5. *Women are given into marriage as children* ($d_g^o > 0, d_g^y = d_w^o = d_w^d = 0$).

Proof. See Appendix B.1. □

The intuition for the age gap is as follows. Given the positive price, fathers have an incentive to sell their daughters at a young age.[20] Also, men like to marry someone of a younger cohort, since this allows him to have children later in life. In equilibrium, the age gap allows every man to have multiple wives, which would not be possible otherwise.

It is now possible to solve for all variables as a function of the equilibrium number of children per man. The population dynamics equation (3) gives the population growth factor: $\eta = \sqrt{\frac{f}{2}}$. Market clearing for girls (5) together with the population growth factor gives the number of wives $n_g^y = \sqrt{\frac{f}{2}}$. This shows that as long as women have at least two children, polygyny is possible despite a balanced sex ratio and a homogenous population.[21] Polygyny is feasible because of a growing population and spousal age gaps. Finally, the total fertility rate is $\frac{f}{n_g^y} = \sqrt{2f}$. Using these results, the man's problem simplifies to[22]

$$\begin{aligned} &\max_{c,f,n,s} \ln(c^y) + \beta\ln(c^o) + \gamma\ln(f) \\ &s.t. \;\; c^y + s + pn \leq w \\ &\qquad c^o + g(f,n) \leq (1-\delta+r)s + p\frac{f}{2} \quad . \end{aligned} \tag{7}$$

[20]A famous example of this is the fashion model Waris Dirie, who was supposed to be sold for 4 camels at the age of 10, and therefore fled from Somalia to England. The camels were desperately needed to feed the remaining children. See Dirie and Miller (1998) for her autobiography.

[21]Becker (1974) argued that either a sex ratio imbalance or heterogeneity is necessary for polygyny.

[22]The last term of the utility function drops out because it is constant at $d_g^o = \frac{f}{2}$. Given a positive price, it is optimal to sell all daughters, hence the disutility from unmarried daughters becomes irrelevant.

The first order conditions of this problem are

$$
\begin{aligned}
f: \qquad \frac{\gamma}{f}+\frac{p\beta}{2c^o} &= \frac{\beta}{c^o}\frac{\partial g}{\partial f} && (8)\\
n: \qquad \frac{p}{c^y} &= \beta\frac{1}{c^o}\left(-\frac{\partial g}{\partial n}\right) && (9)\\
s: \qquad \frac{1}{c^y} &= \frac{\beta}{c^o}(1-\delta+r) \quad . && (10)
\end{aligned}
$$

Equation (8) equates the marginal cost and marginal benefit of having children. Note that the marginal cost consists of two parts: the direct utility from a large family and the revenues from selling daughters. Equation (9) equates the marginal costs and benefits from marriage. The marginal cost is the brideprice, while the benefits are the change in the cost of child-rearing. Equation (10) compares the marginal utility from consuming when young to the discounted marginal utility from consumption when old.

4.2 Monogamy

This section characterizes the balanced growth path when polygyny is not allowed. In this world, a man cannot have multiple wives. Of course, if parameters in the polygynous model are such that the equilibrium number of wives is exactly one, then monogamy arises endogenously. This happens if and only if the equilibrium number of children per women is two. For this special case it is irrelevant whether polygyny is allowed or not. To generate interesting comparative statics results, it is therefore useful to restrict the parameter space. As long as population growth is positive (which in this model is equivalent to a total fertility rate of more than 2), the one-wife constraint binds, and the balanced growth paths of the two regimes are different. One additional assumption is needed for the results in this section.[23]

Assumption 2 *Assume $v'(0)$ is large.*

Assumption 2 is needed to guarantee that a man is willing to pay large enough dowries to guarantee marriage for all of his daughters.[24] Lemma 1 in Appendix B.2 states that under

[23]Unfortunately no closed form solution for the assumption can be derived. However, given parameter values, the lower bound for $v'(0)$ can be computed numerically.

[24]Without this assumption there exists a monogamous equilibrium with an age gap and some never married women. However, the proportion of unmarried women would be unrealistically high.

Assumption 2 men marry women their own age as long as the population is growing. Given that populations are growing in most developing countries, for the remainder of the paper I will focus on parameters such that population growth is strictly positive.[25] This will also guarantee that the one-wife constraint is binding and that monogamy does not arise endogenously. The next proposition characterizes the balanced growth path for this case.

Proposition 2 *Any symmetric balanced growth path with positive population growth has the following features:*

1. *Each man marries exactly 1 wife.*
2. *There is no age gap between husband and wife:* $n_w^y = 1$ *(and* $n_g^y = n_w^o = 0$*).*
3. *Men have children when they are young* ($f^y > 0, f^o = 0$)*.*
4. *Women are given into marriage as young adults* ($d_w^o > 0, d_g^y = d_g^o = d_w^d = 0$)*.*
5. *Population growth is* $\eta = \frac{M_{t+1}}{M_t} = \frac{f^y}{2}$*.*

Proof. Given the assumption of positive population growth, 1 and 2 follow from Lemma 1 in the Appendix. Then, since men marry a fertile wife when young, the child production technology implies that men have children while they are young, which is part 3. Market clearing together with part 2 says that only adult daughters are given into marriage. By part 3, adult daughters have old fathers. This implies $d_w^o > 0$, and all other daughter variables are zero, which is part 4. By Assumption 2 we know that all daughters are sold, $d_w^o = \frac{f^y}{2}$. Using this and $d_w^d = n_w^o = 0$ (from 2 and 4), market clearing (equation 6) can be used to solve for the population growth factor $\eta = \frac{f^y}{2}$, which is part 5. □

Under one additional assumption, it can be shown that the brideprice in the monogamous society is strictly negative. The intuition is that men would prefer to postpone marriage and child-bearing because the discounted cost of children decreases with child-bearing age. However, with population growth this would leave some women unmarried.

[25] Of course, population growth is an endogenous variable. Ideally, one would like to identify sufficient conditions that guarantee an equilibrium total fertility rate of more than 2. This is difficult since no analytical solution for fertility exists, but there are many examples that satisfy this assumption. Intuitively, γ must be large enough and ϵ not too large, given the other parameters.

Fathers are willing to pay a negative price to assure their daughters' marriages. The equilibrium brideprice is such that it makes men indifferent between marrying when old or when young. This is proved formally in Proposition 3 in Appendix B.2.

Note also that this brideprice is not unique. Any other negative price that is bigger in absolute value also clears the market. A general indeterminacy result in the marriage price within monogamous societies was first pointed out by Becker (1973): If the sex ratio is one and there is no heterogeneity, then *any* price (positive or negative) is associated with an equilibrium, as long as the price is such that everyone prefers marriage over remaining single. The intuition is that a sex ratio of one leads to flat supply and demand curves. In this paper, despite a sex ratio of one and homogenous agents, the indeterminacy is considerably reduced. In particular, Proposition 3 gives conditions such that the price is always strictly negative. The reason for this reduction in the indeterminacy is related to the biological fecundity difference between men and women and the endogenous choice of marriage age. This lets the effective sex ratio deviate from one. The goal of marriage in this model is to produce children. Men could do this either with women from their own cohort or with women born a period later. Given a growing population, there will always be more people in the later cohorts, which would lead to a surplus of brides if the "wrong" marriages were made. To avoid this, women (or in this case their fathers) are willing to pay.

Using the results above, the problem of a man can be written as:

$$\begin{aligned} &\max \ln(c^y) + \beta \ln(c^o) + \gamma \ln(f) \\ &c^y + s + p + g(f,1) \leq w \\ &c^o \leq (1-\delta+r)s + p\frac{f}{2} \end{aligned} \tag{11}$$

The first order conditions are

$$f: \qquad \frac{\gamma}{f} = \frac{1}{c^y}\left(\frac{\partial g}{\partial f}\right) - \frac{p\beta}{2c^o} \tag{12}$$

$$s: \qquad \frac{1}{c^y} = \frac{\beta}{c^o}(1-\delta+r) \tag{13}$$

4.3 Comparison Polygyny vs. Monogamy

Comparing the results from Sections 4.1 and 4.2 shows that polygynous and monogamous societies differ considerably. Most importantly, in the polygynous economy, men have to pay a positive price for a bride at marriage, while the equilibrium price in the monogamous economy is negative.[26] This is in line with empirical observations (see Section 2). This different sign of the brideprice has an effect on the incentives to have children. Equations (8) and (12) show that transfers at their daughters' marriages provide an additional incentive to have children for polygynous men, while they add to the cost of child-rearing for monogamous men.

The second crucial difference is that women in the polygynous economy marry earlier than women in the monogamous economy. Since men in both societies marry at the same age, this leads to a higher spousal age gap in the polygynous economy. It also means that men have children later in life in the polygynous economy. This postpones the cost of child-rearing, which lowers the present discounted value of the child-rearing cost and thus provides an additional reason for why polygynous men have more children. This effect can be seen by comparing the first order conditions (8) and (12).

These demographic differences between polygynous and monogamous countries are confirmed by the data (see Section 2). Men in almost all polygynous countries pay a brideprice at marriage, while dowry payments are very common in monogamous countries. Women marry 5 years earlier and the percentage of married female teenagers is more than triple in polygynous countries compared to monogamous countries.[27] Secondly, the age gap is 4 years higher in the high polygyny group. Male marriage ages differ much less, the gap is only one year. The model also implies that the male age at childbirth is higher under polygyny. Unfortunately no cross country data on the average age at child birth is available to verify this implications.

[26]The intuition that outlawing polygyny reduces demand and hence leads to a decrease in the brideprice was first pointed out by Becker (1974), see also Grossbard (1978). However, so far no mechanisms have been suggested explaining why this decrease in the brideprice would lead to a negative price.

[27]In traditional African societies, girls were frequently promised in marriage while they were infants, or even before they were born (Meekers 1992).

5 Calibration and Numerical Results

The main hypothesis of this paper is that polygyny decreases savings and increases fertility, which lowers the capital stock and thus depresses output per capita. This section assesses the importance of these channels quantitatively. The counterfactual experiment here is, suppose family structure (polygyny or monogamy) was the *only* difference between two countries, how distinct would they be? In particular, how much of the income and fertility differences between the highly polygynous Sub-Saharan African countries, on the one hand, and monogamous countries close to the equator, on the other hand, can be explained solely on the basis of family structure?

The model is calibrated to the average of polygynous countries (see Table 1). This means that parameters are chosen such that the steady state matches the fertility rate and savings rate as observed in polygynous countries. The numerical experiment is to compute the monogamous steady state using the same parameters and compare the two steady states.

5.1 Calibrating the Polygynous Economy

I assume the functional form $g(f,n) = \epsilon\frac{f^2}{n}$ for the cost of child-rearing.[28] Recall that $g(f,n)$ is the cost incurred by the man and that each wife pays an additional $\frac{g(f,n)}{n}$. This functional form abstracts from externalities among wives and therefore has the advantage that the cost function for women is identical under both family arrangements: The cost to a woman of bearing f children is ϵf^2 in both economies.

Then the model has 6 parameters that need to be calibrated to derive quantitative results: two utility parameters γ and β, three technology parameters A, α and δ and one parameter in the child-production technology, ϵ.

To determine the appropriate values for the parameters, some assumptions linking the model to observable data need to be made. Firstly, a model period is chosen to be 15 years because that is roughly the age when fecundity starts for most women. Moreover, life-expectancy in most of the countries of interest is between 40 and 50 years, which

[28]This cost function corresponds to a constant returns to scale production function. The corresponding production function is $f = f(n,g) = \sqrt{\frac{ng}{\epsilon}}$, where g is the consumption good input into child production.

Table 3: Calibration Overview

Parameter	Value	matched to fit
γ	0.39	surviving number of kids = 5.04
β	0.46	annual discount factor = 0.95
ϵ	32.3	$\frac{S}{Y} = 14\%$
A	437	GDP p.c. normalized to 1029
α	0.4	income share of capital = 40%
δ	0.66	7% annual depreciation

Table 4: Numerical Results (Benchmark)

	Polygyny model & data	Monogamy model	Monogamy data
Surviving fertility	5.04	2.89	3.56
Savings rate	0.14	0.19	0.18
GDP per capita	1,029	2,458	2,587

makes three 15-year periods an appropriate choice. Secondly, since this model abstracts from mortality, I define fertility in the model as the number of children who survive until at least age five (surviving fertility).

The TFP parameter A is a pure scale parameter used to normalize per capita output to the level in the data, \$1029. The annual discount factor is set equal to 0.95 in line with the macro literature. Annual depreciation of 7% corresponds to $\delta = 0.66$. Following Gollin (2002) I set the capital-share of income to 40 percent, $\alpha = 0.4$. The remaining 2 parameters, γ and ϵ, are calibrated to match the surviving number of children and saving rates from Table 1. Table 3 summarizes the calibration.

5.2 Results

Table 4 summarizes the main results. It shows that allowing for polygyny induces men to marry several wives, to have more children, and to save less. The table shows that the

Table 5: Further Implications of the Model

	Polygyny		Monogamy	
	Model	Data	Model	Data
Wives per man	2.5	1.4	1	1
Age gap	15	7	0	3
Annual population growth	6.3%	2.7%	2.5%	2.0%
Total child-rearing costs/GDP	0.20		0.04	
Total marriage payments/GDP	0.04		0.10	
Male utility	12.0		12.4	
Female utility	11.4		12.2	

magnitudes predicted by the model compare well to the data. The monogamous steady state leads to a fertility rate that is 43% lower than the monogamous one, compared to a 29% lower fertility rate in the data. The model also predicts that savings are about 35% higher under monogamy, which again compares well to the data. Output per capita is 2.3 times the polygynous output, while in the data it is 2.5 times as high. The robustness of these results to changes in parameters is discussed in Appendix C.

Table 5 summarizes further implications of the model. The first part compares the model's implied average number of wives, population growth rates, and age gaps to the data. The model does less well in replicating the demographic features of the data quantitatively. This is partly due to the limited number of periods, and partly due to abstracting from mortality. However, the model is able to replicate the demographic differences qualitatively. Recall that, due to the limited number of periods in the model, the age gap can only be either 0 or 15. Under polygyny, it turns out to be 15, which is about twice the observed number. The average number of wives and the population growth rates implied by the model are also significantly higher than observed in the data. The reason is that mortality is not taken into account here. If people died during the ages 5 and 45 in my model, then population growth would be much lower than what is reported in Table 5, which would also lower the average number of wives.

Table 5 also reports the size of marriage payments and the total amount of resources spent on child-rearing in the model. Note that marriage payments vary considerably across regimes. The amount spent on brideprices in the polygynous economy is less than half of what is spent on dowries in the monogamous economy. This shows that it is not necessary for brideprices to be large in order to have large effects on aggregate savings. Brideprice payments are only 4% of GDP. The table also shows that total expenditures on children are much higher under polygyny than under monogamy. In fact, 20% of GDP is spent on producing children in the polygynous economy, while only 4% of resources are devoted to child production in the monogamous economy. The reason for this large difference is not only due to the higher fertility in the polygynous economy. It is also due to a higher average child cost because fertility per wife is higher under polygyny and marginal costs of children are increasing. These additional predictions could be used to further assess the reasonableness of the model. Since data on these magnitudes is not easily available, this is left for future work.

5.3 Welfare

A natural question to ask is which regime people would prefer. The increased utility from more children under polygyny could in principle outweigh the lower GDP per capita. However, Table 5 shows that steady state utility for both men and women is higher under monogamy. This shows that a ban on polygyny would benefit both men and women. Why is a restriction on the consumers problem beneficial in this framework? First, note that the comparison above is a steady state comparison. If a country in the polygynous steady state unexpectedly passed a law that outlawed polygyny, it is not true that indeed *everybody* would benefit from this. The initial old men would be worse off, because they own an "asset" (daughters) that suddenly loses its value. But could the initial old be compensated? It is unclear whether this is possible. Essentially one would like to know if the polygynous steady state is efficient or if it is Pareto dominated by some other allocation. However, Pareto efficiency is not defined for models with endogenous fertility. In Golosov, Jones, and Tertilt (2003), we propose several extensions to Pareto efficiency that cover the endogenous fertility case. My conjecture is that neither the polygynous nor the monogamous steady state are efficient according to the proposed concepts. An externality in child-rearing is present in both models since the private return on children (direct utility and brideprice) is not equal to the social return (direct utility and wages). More children mean a lower capital-output ratio, and therefore lower wages. This effect is not taken into account by parents making fertility decisions. This externality may be mitigated under monogamy since the negative brideprice effectively constitutes a tax on having children, while the effect is reinforced under polygyny where the positive brideprice decreases the private marginal cost of fertility.

6 Change in Property Rights

It might be difficult to enforce a law that bans polygyny. Moreover, in this model, there is nothing intrinsically wrong with marrying multiple wives. One would therefore like to know whether it is possible to achieve a similar GDP increase without restricting marriages. The reason savings are low under polygyny is that the implied high brideprice makes daughters a valuable asset and crowds out investment in physical capital. So if there was an alternative way of lowering the return on daughters, then this should also lead to higher savings and GDP per capita.

A policy that development agencies have recently emphasized is to improve property rights for women.[29] Currently, the rights to own assets, to inherit, and to make decisions are still limited for many women in developing countries. In the model presented in this paper, fathers have the property right over their daughters, and thus can sell them without restrictions. Transferring this right from fathers to daughters would obviously reduce the return on on wives as now the daughters would be the recipient of the brideprice.

In this section, I analyze whether letting women make their own marriage decisions and reap the benefits has quantitatively big effects. As in the main model, I assume children (male and female) do not make any decisions. In particular, this means that female children cannot sell themselves. The bride choices for a man therefore reduce to two alternatives: brides married when young, n^y, and brides married when old, n^o.

[29] See for example United Nations Human Settlement Programme (2002).

Thus, the man's problem under the policy can be written as:

$$\begin{aligned} \max \quad & \ln c^y + \beta \ln c^o + \gamma \ln(f^y + f^o) - v(\frac{f^y + f^o}{2} - d) \\ & c^y + p^y n^y + s + \epsilon \frac{f^y}{n^y} f^y \leq w \\ & c^o + p^o n^o + \epsilon \frac{f^o}{n^o} f^o \leq (1 - \delta + r)s \quad , \end{aligned}$$

where f^y and f^o are the number of children born when young and old respectively, c^y and c^o are consumption when young and old, and s are savings. As before d denotes the number of married daughters, but it is no longer a choice variable for the man.

A women can choose to sell herself to either type of husband (one who is her age or one who is older than she is). Since her husband makes the fertility decision, she is not necessarily indifferent about the age of her husband at marriage. Given a husband choice $i = y, o$, her problem is

$$\begin{aligned} V^i = \max_{c^y, c^o, s} & \ln c^y + \beta \ln c^o + \gamma \ln(\frac{f^i}{n^i}) - v(\frac{f^i - d}{2n^i}) \\ & c^y + s + [\epsilon(\frac{f^i}{n^i})^2 - p^i] \leq w \\ & c^o \leq (1 + r - \delta)s \quad . \end{aligned}$$

As before, she takes her husband's decisions regarding fertility, f^i, and his other wives, n^i, as given, and only chooses her own consumption, c^y and c^o, and savings, s. Let $I^i,\ i = y, o$ denote a woman's marriage decision: $I^y = 1$ means that she marries a young man, this is optimal if $V^y \geq V^o$. $I^o = 1$ means that she marries an old man, which is optimal if $V^o \geq V^y$.

The definition and characterization of the balanced growth path for this model are provided in Appendix D. The steady state looks qualitatively very similar to the polygynous one when fathers had the property rights over their daughters. The equilibrium brideprice is strictly positive. There is an age gap between husband and wives. The number of wives is equal to the population growth rate. Thus this new policy has a much smaller impact on the demographic features of the equilibrium than enforcing monogamy. Enforcing monogamy changes the structure of the family, the spousal age gap, and the sign of the marriage payment. None of these effects occurs with this new policy, yet the return on wives is decreased, which affects equilibrium savings.

Table 6: Change in Property Rights

	Polygyny		Monogamy
Marriage decision	Father	Daughter	Father
Children per woman	5.04	4.5	2.89
Number of wives per man	2.52	2.25	1
Savings rate as share of GDP	14%	20%	19%
GDP per capita	1,029	1501	2,458
Male steady state utility	12.0	12.2	12.4
Female steady state utility	11.4	12.2	12.2
Total marriage payments/GDP	0.04	0.13	0.10
Total child-rearing costs/GDP	0.20	0.12	0.04

The quantitative results for the benchmark calibration are summarized in Table 6. The first and last column repeat the results from Section 5, while the middle column shows the results of the new policy. As conjectured, the policy significantly increases the incentives to save because daughters no longer function as old age insurance. The savings rate increases by 42% and reaches a level similar to the monogamous one. This leads per capita output to increase by 45%. Note that per capita output is still well below the monogamous level. The reason is that fertility remains high under the new policy experiment. Hence, the ratio of working population to overall population is low, leading to low per capita output. Output per worker, on the other hand, is very similar under both policies. The fertility rate and the number of wives decreases only slightly. This means that the policy hardly changes the structure of families: polygyny and fertility remain high, and spousal age gaps persist. Fertility remains high, despite a considerably higher child cost, because of the higher steady state income, which makes people willing to spend more resources on children.

The above exercise shows that enforcing monogamy is not the only way of improving living standards in polygynous countries. However, the increase in GDP is significantly lower than what enforcing monogamy would achieve.

7 Discussion

This paper analyzed the macroeconomic consequences of allowing men to marry multiple wives. It was shown that banning polygyny has large effects along several dimensions. The increased demand for wives created by allowing polygyny causes the value of a brides to be strictly positive, while it is typically negative when men are restricted to marrying one wife. Therefore, when polygny is allowed, buying wives and later selling daughters becomes a profitable investment strategy that partially crowds out investment in physical assets. The positive brideprice acts like a subsidy to child-rearing which increases fertility. Low investment and high population growth both contribute to a lower capital-output ratio, and thereby to lower output per capita. The numerical experiment shows that enforcing monogamy reduces fertility by 40%, increases savings by 30% and raises the capital-output ratio as well as output per person by 150%. These magnitudes compare well to the data. This suggests that although the practice of polygyny is certainly not the sole cause of poverty it is an important contributing factor for continuing underdevelopment in those places where it is practiced on a large scale.

I also analyzed what would happen if in a polygynous society women were able to make their own marriage decisions and be the recipients of the brideprice. I found that this policy also substantially increases the incentives to save and GDP per capita. The effects on fertility and the number of wives, on the other hand, are relatively small. This finding is interesting because it shows how an increase in living standards could be achieved without forcing people to change their marriage customs completely.

I also found that steady state utility for both men and women is higher under monogamy. This seems to imply that everyone would benefit from a law that prohibits polygyny. Perhaps this explains why indeed many countries have such laws.[30] On the other hand, it raises the question, why wouldn't all countries enforce monogamy then? As emphasized in Section 5.3, the welfare comparison is a statement about steady states and it is not clear that along the transition all consumers would be better off.

[30] Alternatively, some people have argued that polygyny arises when relative female labor productivity is extremely high, for example in countries where hoes are used for cultivating land. As countries move to plow cultivation, men prefer to invest in machines instead of wives and polygyny disappears. See Jacoby (1995) and Boserup (1989).

In particular, the initial old might object to such a change. To further explore these issues, one would need to look at the transitional dynamics. Suppose a country was in the polygynous steady state, and a law was proposed for banning polygyny from now on for all future generations. Who would vote for such a law? Similarly, which (if any) members of a monogamous society would vote for a law that allows marriages to multiple wives for current and all future generations? Computing transitional dynamics would be necessary to answer these questions. This is left for future research.

Several modelling choices were made to make the model tractable. One would like to know how sensitive results are to these choices. In the remainder of this section, I discuss a few extensions and modifications.

A modelling choice that was made to keep the model tractable concerns the way children enter into the utility function. Fathers derive utility from the total number of children, but do not differentiate between children born earlier vs. later in life. In particular, I have assumed that children born later in life are not discounted. Without this assumption, men might prefer to have children when young and this could affect my qualitative results. It would be interesting to explore the following different specification. Suppose parents were altruistic in the sense of Barro and Becker (1989). Altruistic parents would take the trade-off between quantity and quality of children into account. This could potentially induce parents to have fewer children and save more, leading to a higher capital stock and higher wages for the children. This could be quantitatively very important. However, since this effect would be present under both family arrangements, it is unclear whether the quantitative *differences* between the two environments would change much.

The model assumes that women are not involved in the fertility decision. One would like to know how robust the findings are to intra-family bargaining. What would happen if a wife could pay her husband in exchange for having fewer children? Would this significantly alter the results? In other words, how inefficient is the intra-family decision process? Any efficient outcome to a bargaining game between spouses can be found as a solution to the following problem: The husband chooses all variables subject to the constraint that his wife (wives) receive(s) utility $\bar{U}$. By choosing various values for $\bar{U}$, differences in bargaining power between spouses can be captured. Preliminary results show that incorporating efficient bargaining into the model does not change the results qualitatively. Obtaining quantitative implications is less obvious. How would one calibrate the bargaining power, i.e. the utility level for women? And should one choose the same $\bar{U}$ under polygyny and monogamy? This may lead to the wrong comparison, because, as seen before, polygyny leads to lower GDP per capita. Hence, equalizing utility for women across regimes would imply that women are receiving very different *shares* of total output under the two regimes. On the other hand, choosing different female utility levels across the two regimes raises the question of how to determine this difference. Independent evidence on bargaining power of women in various countries would be needed.

Another way to test how robust the results are with respect to intra-family decision making would be to modify the model as follows. Assume that the only role of women is to produce children. Then women could be modelled solely as an input into child production, but there would not be a separate maximization problem for women. I have solved this modified problem and find qualitatively similar results. More details on this alternative specification are available upon request.

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A Data Appendix

Table 7 includes all countries where more than 10% of married men have multiple wives.[31]

Table 7: Polygynous Countries

Country	Sex Ratio	Pol1	Pol2	Price	TFR	CMR	Gap	Marr1	Marr2
Malawi	50.8	10.2	.	B	7.6	265	5	43.6	98.2
Bangladesh	49.6	11.3	.	BD	6.1	211	7.5	51.3	99.3
Kuwait	46.8	11.7	.	.	5.3	35	3.3	13.2	96.3
Kenya	49.9	12.5	1.2	B	7.8	115	5.2	16.7	98.8
Centr. African R.	51.2	13.3	1.3	B	5.8	.	5	42.3	99.0
Niger	50.6	15.2	1.3	B	8	317	6.8	61.9	99.6
Uganda	50.0	15.8	.	B	7.2	180	4.3	49.8	96.9
Sudan	49.7	15.9	1.2	B	6.1	145	5.9	21.3	96.3
Tanzania	50.4	15.9	1.2	B	6.7	176	5.8	.	97.1
Ghana	50.2	16.3	1.2	B	6.5	157	7.5	22.4	98.9
Congo (Zaire)	50.5	19.5	1.3	B	6.6	210	5.3	74.2	95.4
Cote d'Ivoire	49.2	20.2	1.3	B	7.4	170	7.8	27.7	98.4
Chad	50.5	22	.	B	6.9	235	6.5	48.6	100
Gabon	50.5	27.3	1.4	.	4.5	.	7.8	15.9	87.2
Mali	51.0	29.3	1.3	B	7.1	.	9.2	49.7	99.6
Benin	50.7	31	1.4	B	7	214	6.6	29.1	.
Congo	51.0	31.9	1.6	B	6.3	125	5.1	55.5	92.9
Togo	50.3	31.9	1.5	B	6.8	188	8	19.9	98.9
Guinea	49.7	37.1	1.6	B	6.1	.	10.8	49	99.7
Burkina Faso	50.5	40.2	1.7	B	7.5	.	8.6	34.6	97.2
Senegal	50.2	40.7	1.5	B	6.8	.	8.4	43.8	95.4
Cameroon	50.0	55.6	1.4	B	6.4	173	7.4	35.8	99.2
Average*	50.3	24.4	1.38		6.73	192	6.89	39.65	97.4

Comments: · indicates no data available

* Kuwait is excluded from this average because of its extremely high income due to oil reserves.

Sex ratio: Percentage of the population that is female.

Polygyny 1: Percentage of married men in a polygynous union

Polygyny 2: Average number of wives per married men

Price: B=Brideprice, D=Dowry

TFR: Number of births per women, 1980

[31] Polygynous countries where less than 10% of all marriages are polygynous are Iran, Algeria, Syrian Arab Republic, Egypt, Pakistan, Morocco, Libya, Lebanon, Jordan, Tunisia, Yemen, India, Bahrain, Iraq, United Arab Emirates, Oman, and many Sub-Saharan African countries.

CMR: Number of live births per 1000 that die before the age 5, 1980

Gap: Average marriage age of men minus average marriage age of women

Marr1: Proportion of ever-married women aged 15 to 19

Marr2: Proportion of ever-married men aged 45-49

See Appendix A.1 for data sources.

A.1 Data Sources

Data on polygyny is from the United Nations (1990) and from Bankole and Singh (1998). Fertility and mortality rates are from the World Bank (2002). The UN Population Division (2000) provides data on the fractions of men and women that are married, as well as on average ages at first marriage and the age gap between husbands and wives. Population growth rates and life expectancy is from the Population Reference Buerau (2000). The sex ratio comes from the World Development Indicators (World Bank 2003). The macroeconomic variables (capital-output ratios, investment rates and GDP per capita) are from the Penn World Tables, Version 5.6a (1995). See Summers and Heston (1991) for a description of the Penn World Tables.

B Solving the Model

B.1 Polygyny

Proof of Proposition 1

Part 1 is very intuitive. Suppose $p_t^g \leq 0$ for some period t. Then a man would buy an infinite amount of wives because this would strictly decrease child-rearing costs. This cannot be an equilibrium. Equally, if $p_t^w \leq 0$, a man would demand an infinite number of wives. Part 2 and 3 of the proposition can be proved by showing that the 'wrong' wife choices always lead to a contradiction between market clearing and the first order conditions. For part 2, assume that $n_w^y > 0$. Then, there has to be someone supplying adult daughters: $d_w^o > 0$ or $d_w^d > 0$. But $d_w^d > 0$ is never optimal given that $p^w > 0$ and given the no borrowing constraint. Next, $d_w^o > 0$ implies that fathers have some children when young, $f^y > 0$. Can this ever be optimal? The possibility of corner solutions implies that the first order conditions may or may not be binding and that different cases need to be considered. Consider first the case where $n_w^o = 0$ and $d_w^o = \frac{f^y}{2}$ and all other variables are strictly interior. Manipulating the first order conditions for this case, and using market clearing, it can be shown that this would be an optimal choice only if $p^g = p^w$. This would also imply that $\frac{c^o}{c^y \beta} = 1$. However, because savings are possible, we also have $\frac{c^o}{c^y \beta} \geq (1 + r - \delta) > 1$. Which leads to a contradiction. All other cases can be ruled out by a similar logic. In essence, as long as $n_w^y > 0$, there is no price vector (p^g, p^w) at which $n_w^y > 0$ is optimal and markets clear. A similar logic works for part 3. Assuming that $n_w^o > 0$, a contradiction between market clearing and optimization behavior can be derived. Part 2 together with the observation that fertile wives are needed for child-production gives $f^y = 0$, proving 4. Part 3 together with market clearing implies that all daughters are given into marriage as children. Since by part 4 only old men have young daughters part 5 follows immediately. □

Existence

The following proof by construction assumes a functional form for the cost of child-rearing, $g(f, n) = \epsilon \frac{f^2}{n}$. However, the same logic should work more generally, as long as the child-rearing function is convex. To prove that a balanced growth path (BGP) exists, it needs to be shown that there exit stationary prices and an allocation such that markets clear and agents are optimizing. By Proposition 1 we know that if a BGP exists, it has very specific characteristics. It was also shown that the following relationship between the number of wives and children has to hold: $n = \sqrt{\frac{f}{2}}$. It still needs to be shown that there exists a price vector (p^g, p^w) such that these choices are optimal and markets clear.

One problem in showing that the man's problem has a solution is that the budget set is non-convex due to the cost function on the left-hand side of the budget constraints. However, a simple change of variables makes the problem convex. Denote investment in children when young and old by I^y and I^o respectively. Then the "production function" for children is $f^i = \sqrt{\frac{I^i n^i}{\epsilon}}$, where n^i is the number of fertile wives and $i = y, o$. In the modification, a man chooses two types of input into child production, which then implies "child output." The modified problem is isomorph to the original one. Given positive prices (see Proposition 1), the last part of the utility function becomes irrelevant and is therefore omitted here. Positive brideprices together with the no-borrowing constraint also imply that a man would never arrange a marriage for after his death. Hence $d_w^d = 0$. This implies that a man would want all daughters born when he is old to be married during that period, $d_g^o = \frac{f^o}{2}$. These simple arguments are used below to eliminate a few choice variables from the man's problem.

$$\begin{aligned}
\max_{I^y, I^o, d_w^o, n_g^y, n_w^y, n_w^o} \quad & \ln(c^y) + \ln(c^o) + \gamma \ln(f^y + f^o) \\
& c^y + s^y + p_g n_g^y + p_w n_w^y + I^y \leq w + p^g\left(\frac{f^y}{2} - d_w^o\right) \\
& c^o + s^o + p_w n_w^o + I^o \leq (1+r)s^y + p_g \frac{f^o}{2} + p_w d_w^o \\
& d_w^o \leq \frac{f^y}{2} \\
& f^y \leq \sqrt{\frac{I^y n_w^y}{\epsilon}} \\
& f^o \leq \sqrt{\frac{I^o (n_g^y + n_w^o)}{\epsilon}} \\
& \text{non-negativity constraints on all variables}
\end{aligned} \tag{14}$$

This problem is convex and hence the first order conditions are necessary and sufficient conditions for a maximum.

$$\begin{aligned}
I^y: \quad & \frac{\gamma}{f^y + f^o} \frac{\partial f^y}{\partial I^y} + \frac{\gamma}{2} \frac{\partial f^y}{\partial I^y} + \frac{p_g}{2c^y} \frac{\partial f^y}{\partial I^y} \leq \frac{1}{c^y} \\
I^o: \quad & \frac{\gamma}{f^y + f^o} \frac{\partial f^o}{\partial I^o} + \frac{\beta p_g}{2c^o} \frac{\partial f^o}{\partial I^o} \leq \frac{\beta}{c^o} \\
n_w^y: \quad & \frac{\gamma}{f^y + f^o} \frac{\partial f^y}{\partial n_w^y} + \frac{\gamma}{2} \frac{\partial f^y}{\partial n_w^y} + \frac{p_g}{2c^y} \frac{\partial f^y}{\partial n_w^y} \leq \frac{p_w}{c^y} \\
n_g^y: \quad & \frac{\gamma}{f^y + f^o} \frac{\partial f^o}{\partial n_g^y} + \frac{\beta p_g}{2c^o} \frac{\partial f^o}{\partial n_g^y} \leq \frac{p_g}{c^y} \\
n_w^o: \quad & \frac{\gamma}{f^y + f^o} \frac{\partial f^o}{\partial n_w^o} + \frac{\beta p_g}{2c^o} \frac{\partial f^o}{\partial n_w^o} \leq \frac{\beta p_w}{c^o} \\
d_w^o: \quad & \frac{\beta p_w}{c^o} \leq \frac{p_g}{c^y} + \psi \\
s^y: \quad & (1+r)\frac{\beta}{c^o} \leq \frac{1}{c^y} \\
C.S.: \quad & \psi\left[\frac{f^y}{2} - d_w^o\right] = 0
\end{aligned}$$

All equations hold with equality if the respective variable is strictly positive.

Guess that the solution has the following characteristics: $f^y = 0, f^o > 0, I^y = 0, I^o > 0, n_g^y > 0, n_w^o = n_w^y = d_w^o = 0, s > 0$.[32] Given the guess, only the FOCs with respect to

[32]This guess is based on the characterization results summarized in Proposition 1.

I^y, n_w^y, and s have to hold with strict equality. It is straightforward to verify that as long as $p^w \geq \frac{c^o}{\beta c^y} p^g$, none of the FOCs that have to hold with weak inequality is violated. One can then use the FOCs with respect to n_w^y and s to solve for p^g and for s analytically as a function of the number of children, f. All other variables can then also be expressed as a function of f. Then the first order condition with respect to I^y can be used to solve for the equilibrium f, using the production function for children. This turns out to be a polynomial of degree 4. Let $X = 2\beta\epsilon + \frac{\gamma}{1+\beta}\beta\epsilon - \frac{\gamma}{1+\beta}\epsilon + \gamma\epsilon$, $Y = \frac{\beta\epsilon}{1-\delta+r} - \frac{\epsilon\gamma}{(1+\beta)(1-\delta+r)} + \frac{\gamma\epsilon}{1-\delta+r}$, and $Z = \frac{\gamma}{1+\beta}\beta(1-\delta+r)w$. Then the relevant equation becomes

$$Y^2 f^4 - 2X^2 f^3 + 2YZf^2 + Z^2 = 0 \tag{15}$$

As long as this equation has a real strictly positive root, a solution to the maximization problem (given w and r) exists and it is straightforward to show that prices (w, r) exist that clear the markets for labor and capital. Then a non-trivial balanced growth path exists. However, for certain combinations of parameters, the polynomial has no positive root. In these instances, the only equilibria are non-stationary.

B.2 Monogamy

Lemma 1 *On the balanced growth path, either*

1. $n_w^y = 1$ *(and* $n_g^y = n_w^o = 0$*) or*
2. $\eta \leq 1$

Proof. Adding the two market clearing equations (5) and (6) gives

$$(d_g^y + d_w^o)\eta + d_g^o + d_w^d = (n_g^y + n_w^o)\eta + n_w^y \eta^2.$$

It follows from Assumption 2 that a father will sell all his daughters (independent of the brideprice). This can be used to rewrite the equation above in terms of children born:

$$\frac{f^y}{2}\eta + \frac{f^o}{2} = (n_g^y + n_w^o)\eta + n_w^y \eta^2$$

From the population law of motion (3) it follows that the left-hand side is equal to η^2, which can be used to rewrite the equation as

$$\eta = (n_g^y + n_w^o) + n_w^y \eta \tag{16}$$

Equation (16) together with the constraint from the man's problem that $n_g^y + n_w^o + n_w^y \leq 1$ implies that either $n_w^y = 1$ and $n_g^y + n_w^o = 0$ or that $\eta = \frac{n_g^y + n_w^o}{1 - n_w^y} \leq 1$ $\square$

Equilibrium Dowry

As in the polygynous model, for some parameters, no symmetric BGP exists. For certain parameters, it may also be the case that there is a BGP involving positive brideprices. A complete characterization of these possibilities is difficult to derive. However, the parameters used for the calibration seem to fall well into the range that is used for the following proposition. This section uses the same functional form for the cost of child-rearing: $g(f, n) = \epsilon \frac{f^2}{n}$ as used for the calibration.

Proposition 3 *If* $\frac{wA}{\epsilon(\gamma+2\beta+2)} < 4(1 + r - \delta)$ *and population growth is positive*[33] *then there exists a BGP and it is characterized by negative brideprices,* $p^w = (1 - \delta + r)p^g < 0$.

Proof. This is proved by construction. Proposition 2 says that if a BGP exists it has the following characteristics: $x^* = (n_w^y = 1, n_g^y = n_w^o = 0, f^y > 0, f^o = 0, d_w^o = \frac{f^y}{2}, d_g^y = d_g^o = d_w^d = 0)$. It remains to construct prices (p^g, p^w) that assure x^* is the optimal choice for a man. Let $p^g = \frac{p^w}{1-\delta+r}$. This makes a man indifferent between selling his daughters as girls or selling them as young adults. It also makes a man indifferent between marrying a female child when young, n_g^y, or marrying a young adult when he is old, n_w^o.

It is left to show that marrying an adult bride when young, n_w^y, is weakly better than either of the two other possible brides or any convex combination. Note, however, that since kids are produced with a constant returns to scale technology using wives and the consumption good as inputs, using a convex combination of wives can never be cheaper than simply using the "cheapest" of the three types of wives. It is therefore sufficient to show that $n_w^y = 1$ is weakly preferred to $n_w^o = 1$.

All that is left to show is that there exists a prices $p^w < 0$ which make a man indifferent between marrying when young and marrying when old. Writing the problems using a present value budget constraint makes the comparison more obvious. Let the superscripts 'y' and 'o' stand for the age of a man at marriage. Then the maximization

[33] Again, ideally this should be expressed as an assumption on exogenous parameters only. However, due to the lack of a closed form solution, it is difficult to obtain an explicit characterization of the set of parameters that satisfy this condition. This condition will be a useful check for the calibration exercises. A calibration will uniquely pin down r, w, and f, and hence, the condition can be checked.

problems can be written as follows.

$$V^y(p^w) = \max_{c^y,c^o,f} \ln(c^y) + \beta\ln(c^o) + \gamma\ln(f)$$
$$c^y + \frac{c^o}{1-\delta+r} + g(f,1)f \leq w - p^w\left(1 - \frac{\frac{f}{2}}{1-\delta+r}\right) \tag{17}$$

$$V^o(p^w) = \max_{c^y,c^o,f} \ln(c^y) + \beta\ln(c^o) + \gamma\ln(f)$$
$$c^y + \frac{c^o}{1-\delta+r} + \frac{g(f,1)f}{1-\delta+r} \leq w - \frac{p^w}{1-\delta+r}\left(1 - \frac{\frac{f}{2}}{1-\delta+r}\right) \tag{18}$$

It is obvious from the two problems above, that if $p^w = 0$, a man would prefer to marry when old, but such a choice would not clear the market. Define the value of marrying young but having the same number of kids as a man who marries when old as

$$\tilde{V}^y(p^w) = \max_{c^y,c^o} \ln(c^y) + \beta\ln(c^o) + \gamma\ln(\bar{f}^o)$$
$$c^y + \frac{c^o}{1-\delta+r} + g(\bar{f}^o,1)\bar{f}^o \leq w - p^w\left(1 - \frac{\frac{\bar{f}^o}{2}}{1-\delta+r}\right)$$

It it sufficient to show that there exists a price p s.t. $\tilde{V}^y(p) \geq V^o(p)$ since this implies $V^y(p) \geq V^o(p)$ immediately. To show this, it is sufficient to find a p such that present discounted consumption implied by $\tilde{V}^y$ is higher than implied by V^o. This reduces to

$$-p(1 - \frac{\frac{f^o}{2}}{1-\delta+r}) > g(f^o,1)f^o$$

It is easy to show that f^o increases in p, and hence as long as $f^o(p=0) < 2(1-\delta+r)$ the left-hand side goes to infinity as p goes to minus infinity, while the right-hand goes to zero. By continuity, a price $p < 0$ s.t. the LHS and the RHS are equal has to exist. At this price $\tilde{V}^y = V^o$ and hence $V^y \geq V^o$. It remains to be verified that $f^o(p = 0) < 2(1-\delta+r)$ is indeed true. Solving for f^o analytically gives $f^o(0) = \sqrt{\frac{(1-\delta+r)w\gamma}{\epsilon(\gamma+2\beta+2}}$. Therefore, $\frac{w\gamma}{\epsilon(\gamma+2\beta+2)} < 4(1+r-\delta)$ guarantees that the equilibrium number of kids is small enough for the argument to work. $\square$

C Robustness

To see how sensitive the results are to changes in the parameters, I will report two alternative calibrations here. As was discussed in the main text, population growth in

Table 8: Numerical Results (Robustness)

		Polygyny model & data	Monogamy model	Monogamy data
lowering fertility	Surviving fertility	4.0	2.35	3.56
	Investment rate	0.14	0.16	0.18
	GDP per capita	1,029	2,028	2,587
$\alpha = 0.35$	surviving fertility	5.04	2.46	3.56
	Investment rate	0.14	0.25	0.18
	GDP per capita	1,029	2,911	2,587

the benchmark calibration is too high because the model abstracts from mortality. I therefore recalibrate the model to a lower polygynous fertility rate so that it leads to more realistic population growth. The results are reported in Table 8. This change somewhat reduces the difference in savings rates and output per capita across the two economies. However, magnitudes are still large, with GDP per capita in the monogamous economy being twice as large as in the polygynous economy. Another robustness check concerns the capital share of output. One could argue that 40% is too high because of incorrect measurement of self-employment, and that the true output share of capital is lower. Table 8 therefore reports the results for a calibration to $\alpha = 0.35$. The results show that this would lead to even higher output differences across the two economies.

So the magnitudes are indeed sensitive to the details of the calibration. However, the result that polygyny reduces the incentives to save and thereby leads to low output per capita and that these effects are large is very robust. More robustness results are available upon request.

D Extension: Change in Property Rights

Definition 2 *A symmetric balanced growth path for the economy where women own themselves is an allocation: consumption* (c^y, c^o, c_f^y, c_f^o)*, savings* (s, s_f)*, number of wives* (n^y, n^o)*, female marriage decisions* (I^y, I^o)*, numbers of children* (f^y, f^o)*, and prices* (p^g, p^w, r, w)*, a population growth factor* η *and a capital-output ratio such that*

- *Given prices,* (c, s, n, f) *solves the man's problem.*

- *Given prices and (f, n), women choose $(c_f^y, c_f^o, s_f, I^y, I^o)$ optimally.*
- *Market for same age marriages clears: $n^y M_t = I^y M_t$.*
- *Market for age-gap marriages clears: $n^o M_{t-1} = I^o M_t$.*
- *Firms maximize profit.*
- *Aggregate capital stock and labor input are consistent with individual decisions.*
- *Population dynamics: $\eta^2 = \frac{1}{2}[\eta f^y + f^o]$.*

The first order condition of the man's problem are:

$$
\begin{aligned}
n^y: &\quad p^y && \geq \epsilon(\frac{f^y}{n^y})^2 \\
n^o: &\quad p^o && \geq \epsilon(\frac{f^o}{n^o})^2 \\
f^y: &\quad \tfrac{2\epsilon f^y}{c^y n^y} && \geq \frac{\gamma}{f^y + f^o} \\
f^o: &\quad \tfrac{\beta 2\epsilon f^o}{c^o n^o} && \geq \frac{\gamma}{f^y + f^o} \\
s: &\quad \tfrac{1}{c^y} && = \frac{\beta}{c^o}(1 - \delta + r)
\end{aligned}
$$

where all equations hold with strict equality if the respective variable is strictly positive.

Proposition 4 *Any balanced growth path in the economy where women make their own marriage decision is characterized by the following properties.*

1. $p^y, p^o > 0$
2. $n^y = 0, n^o > 0$ *and* $I^y = 0, I^o = 1$.
3. $n^o = \frac{M_t}{M_{t-1}}$
4. $\frac{M_t}{M_{t-1}} = \sqrt{\frac{f^o}{2}}$

Proof. Part (1) is true because otherwise demand for wives would be infinity, which would violate market clearing. Given part (2), (3) follows directly from the age-gap marriage market clearing condition. Part (2) also implies that young men cannot have any children, $f^y = 0$, which together with the law of motion for population dynamics then implies that fertility and population growth are linked by condition (4). Part (2) is a little more subtle. Note that it follows from the first order conditions of the man's problem that the optimal child/wife ratio is such that the per-wife cost of child-rearing is exactly equal to the brideprice.

$$p^i = \epsilon(\frac{f^i}{n^i})^2 \quad i = y, o \tag{19}$$

Thus, the brideprice exactly covers the child-rearing cost for a women. This implies that the cost cancels out of the woman's problem in equilibrium and that her utility is strictly increasing in own fertilty. Thus, she prefers the husband who wants more children, irrespective of the brideprice. To show that any equilibrium will involve an age gap, consider three cases. Suppose first that $p^y = p^o$. Then a man would choose to marry only women that are younger because this allows him to postpone child-bearing, which makes having children ultimately cheaper. Next, suppose $p^y > p^o$, then men would still strictly prefer to marry when old. So $p^y < p^o$ is necessary to make a man prefer to marry a wife of his own generation. But (19) implies that the number of children per wife is higher for an old man. This means that a woman strictly prefers to marry an older man. Hence there can be no equilibrium in which men and women of the same age marry. □

Using these first order conditions together with the results from Proposition 4 one can solve the model analytically. The FOCs with respect to n^o, f^o, and s have to hold with equality. Marriage market clearing together with population dynamics becomes $n^o = \sqrt{\frac{f^o}{2}}$. The FOC w.r.t. n^o gives $p^o = \epsilon(\frac{f^o}{n^o})^2$. From the budget constraint we have

$$c^o = (1 - \delta + r)s - [p^o + \epsilon(\frac{f^o}{n^o})^2]n^o = (1 - \delta + r)s - [2\epsilon(\frac{f^o}{n^o})^2]n^o \quad .$$

Substituting this into FOC s and solving for s gives:

$$s = \frac{2\epsilon\frac{(f^o)^2}{n^o} + w\beta(1 - \delta + r)}{(1 - \delta + r)(1 + \beta)}$$

Now plugging everything into FOC w.r.t f^o and solving gives

$$f^o = \left\{\frac{\gamma w(1 - \delta + r)}{2\sqrt{2}\epsilon[(1 + \beta + \gamma)]}\right\}^{\frac{2}{3}} \tag{20}$$

The woman's problem can then be written as

$$\max_{c_f^y, c_f^o, s_f} \quad \ln c_f^y + \beta \ln c_f^o$$

$$c_f^y \leq w - s_f \quad \text{and} \quad c_f^o \leq (1 + r - \delta)s_f$$

The solution to this is $s^f = w\frac{\beta}{1+\beta}$. The equilibrium wage and interest rate can then be solved numerically.