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Michèle Tertilt

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Center on Democracy, Development,
and The Rule of Law
Stanford Institute of International Studies
Stanford University
Encina Hall
Stanford, CA 94305
Phone: 650-724-7197
Fax: 650-724-2996
http://cddrl.stanford.edu/

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About the Author

Michèle Tertilt is an Assistant Professor of Economics at Stanford University. She received her Ph.D. from the University of Minnesota and was awarded the Best Dissertation Award, University of Minnesota, May 2004. Her major fields of concentration are: macroeconomics, family economics, growth and development. Terltilt's most recent publication is *"IPUMS - CPS, An Integrated Version of the March Current Population Survey, 1962-2002,"* joint with Miriam L. King, Historical Methods, Winter 2003, Vol. 36, 35-40. Her working papers include: *"Dynamic Marriage Market Accounting – A Note,"* (December 2004); "*Efficiency with Endogenous Population Growth,"* joint with Mikhail Golosov and Larry Jones, NBER Working Paper 10231 (January 2004); "*Consumer Bankruptcy - A Fresh Start*," joint with Igor Livshits and Jim MacGee, Federal Reserve Bank of Minneapolis Working Paper no. 617 (December 2001).

Polygyny, Fertility, and Savings*

Michèle Tertilt†

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Abstract

Sub-Saharan Africa has a high incidence of polygyny. Countries in this region are also characterized by large age gaps between husbands and wives, high fertility, and the payment of a brideprice at marriage. In monogamous countries, on the other hand, the bride's parents traditionally give a dowry (negative brideprice) at marriage. Sub-Saharan Africa is also the poorest region of the world. In this paper I ask whether banning polygyny could play any role for development in Sub-saharan Africa. Since this experiment does not exist in the data, I address the question using a formal model of polygyny and analyze the effects of enforcing monogamy within the model. I find that enforcing monogamy lowers fertility, shrinks the spousal age gap, and reverses the direction of marriage payments. The capital-output ratio and GDP per capita increase. The reason is that when polygyny is allowed, high brideprices are needed to ration women. This makes buying wives and selling daughters a good investment strategy that crowds out investment in physical assets. I show that these effects can be large quantitatively. For reasonable parameter values, I find that banning polygyny decreases fertility by 40%, increases the savings rate by 35% and increases output per capita by 140%.

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†Stanford University, Dept of Economics, 579 Serra Mall, Stanford CA 94305, tertilt@stanford.edu.

1 Introduction

In this paper, I look at differences in marriage laws as a determinant of both fertility and investment rates.[1] 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.

Polygyny is very prevalent in Sub-Saharan Africa (SSA). For example in Cameroon more than 50% of all men have multiple wives. In fact, U.N. data show that 20 countries within this region have polygyny rates of more than 10%. The high polygyny rates indicate that polygyny in SSA is very different from the common perception of a wealthy minority of men having many wives, as is the case in some Arab countries. I compare aggregate variables for these countries to a geographically similar group of monogamous countries and find striking differences. Women in polygynous countries marry on average 4.5 years earlier and have 2.2 children more than women in monogamous countries. The average age difference between husband and wife is 7 years, which is 3.5 years higher than in monogamous countries. In countries with polygyny men pay a positive price for a wife, whereas giving dowries (i.e. paying a negative price for a woman) is very common in monogamous countries. I also find that 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.

The unconditional correlations between polygyny/monogamy and various demographic and economic outcomes are suggestive but obviously not conclusive. Many other factors come to mind as potential explanations for poverty in this region. Colonial history, civil wars, tropical climate, and bad institutions are some of the factors that have been suggested in the literature(see for example Acemoglu, Johnson, and Robinson (2001)). This paper does not try to disentangle the importance of each of these factors. Instead, I ask the question whether simply enforcing monogamy could play a positive role in the development of Sub-Saharan Africa. Since such an experiment does not exist in the data, I address the question of causality by using a formal model of polygyny and by analyzing the effects of enforcing monogamy within the model.

[1] I use the term "law" in a broad sense to mean any rules and norms that are enforced by a society.

[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).

The main idea of this paper is as follows. There is a large asymmetry between the sexes allowing men to make all decisions regarding fertility and marriage arrangements for their daughters. In particular, this means that a father gets to keep any marriage payments made for his daughters, while a son makes his own marriage arrangements and pays or receives his own marriage payments. An equilibrium with polygyny requires a positive brideprice to ration women. This makes children a relatively good investment, since the return on daughters is positive and on sons is zero. It follows that men want many wives and children, so fertility is high. Marriage to multiple wives for all men is possible in equilibrium due to a large spousal age gap and high population growth. It also follows that men save for their old age through their children, so little is invested in physical capital. If polygyny is banned, then a dowry (i.e. negative brideprice) typically evolves in equilibrium. The crucial assumption needed for this result is a male preference for brides who are younger than themselves. Without a dowry such a preference would lead to an equilibrium with large spousal age gaps, which, whenever population growth is positive, would lead to a fraction of women not being able to marry. A second critical assumption is that having single daughters is costly to fathers, and hence a father is willing to pay a dowry to assure her marriage. Having to pay a dowry for each daughter, while again not receiving anything for a son, makes children a poor investment in a monogamous society. It follows that fertility is low and investment in physical assets is high.

The framework used is an overlapping generations model with men and women. Apart from age and sex, people are homogeneous. Fertility is chosen by men. Child production requires two inputs, fecund wives and resources to feed the children.[3] 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 he is. This makes the timing of births for a man endogenous. A representative competitive firm uses capital and labor to produce a consumption good. Wages and interest rates are determined endogenously in equilibrium. 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 calibrate the model to match investment and fertility rates in polygynous SSA. I

[3] I use the word "fecundity" to mean the biological capability of producing offspring, while "fertility" specifies the actual number of children born.

then compute the steady state in the model in which polygyny is banned, using the same parameters. I find that fertility decreases by more than two children per woman. The experiment also shows an increase in the savings rate from 14% to 19%. A higher capital stock and lower population growth rate cause output per capita to go up by 140%.

The economic analysis of the polygyny was pioneered by Becker (1974) and Grossbard (1978) and later formalized and expanded by Bergstrom (1994). Guner (1999) provides an interesting analysis of the interaction of marriage systems and inheritance rules. These papers focus primarily on the marriage market and not on the implications for development. A relatively large literature exists that analyzes the interaction between fertility, savings, and growth (e.g. Barro and Becker (1989), Galor and Weil (1996)). These papers assume that marriages are monogamous.

More recently, several authors have analyzed the interaction between marriage systems and economic growth. Edlund and Lagerloef (2002) argue that polygyny hurts growth by reducing human capital accumulation. The key element is that polygyny creates an asymmetry between the number of children a son vs. a daughter can have, which, if men care about the number of grand-children, induces fathers to favor sons over daughters. This diverts resources from women to men. By assumption, only mothers invest in their children's human capital. Hence, human capital is lower in polygynous societies. Lagerloef (2004) and Gould, Moav, and Simhon (2004) relate the disappearance of polygyny to economic development. Both papers focus on the importance of heterogeneity for generating polygyny and the quality-quantity trade-off in children. Lagerloef (2004) argues that men in primitive societies are very unequal, allowing rich men to marry more wives. Rich men then have more children, which dilutes their wealth over time, making society more equal, which in their model eliminates polygyny eventually. As men choose fewer wives and children, they invest more in their children's human capital. Therefore the decline in polygyny and the decrease in fertility is accompanied by economic growth. Gould, Moav, and Simhon (2004) provide an explanation for the transition to monogamy that is similar, but does not rely on the (arguably counterfactual) disappearance of male heterogeneity. The key assumption in their argument is that higher quality parents have a comparative advantage in producing higher quality children. It is assumed that the skill premium is higher in more developed societies which increases the demand for quality over quantity of children. This leads men to focus on the quantity rather than the quality of wives, and thereby eliminates polygyny eventually. A ban on polygyny may speed up this process. Fertility per woman is exogenous in the model so that a ban on polygyny effectively restricts male fertility. This induces men to invest in child quality instead.

My paper adds to this literature in several respects. It is the first to provide quantitative implications. I calibrate the model and show that for realistic parameter values, banning polygyny has large effects. I also show that male heterogeneity is not a prerequisite for polygyny. As long as men marry younger women, polygyny can occur even when all men are equal. Fertility is endogenous in my model, which is not the case in Edlund and Lagerloef (2002) and Gould et al (2004). Finally, my paper emphasizes the role of physical capital accumulation rather than human capital accumulation. Using a standard constant returns to scale technology in capital and labor allows me to generate wages and interest rates endogenously.[4]

It should be pointed out the marriage market may not be the only determinant of dowry payments. As was first pointed out by Zhang (1994), there may also be a bequest motive for dowries which cannot be entirely separated from the marriage market role. The inheritance role of dowries has been analyzed by Botticini and Siow (2003) and Edlund (2001) among others.[5] Finally, Anderson (2003) analyzes the importance of caste as a determinant of dowry payments.

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 and Section 6 concludes.

2 Empirical Background

When discussing polygyny, most people think of middle-Eastern Islamic countries. But while marrying up to four wives is generally accepted in the Islamic world, 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.

[4]Returns to human capital are also endogenous in Lagerloef (2004), who assumes an externality in knowledge acquisition.

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

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 provides 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 eventually in these countries. The data show that the common perception that two wives for some men means no wives for equally many men is wrong. Since the sex ratios in most countries do not deviate much from one, one may wonder how such a high incidence of polygyny is possible. The answer to this puzzle lies in the extremely high spousal age gaps coupled with high population growth (Tertilt 2004).[6] 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 in cohort size over 7 years. On average each man could therefore marry 1.2 wives, or put differently, 20% of the population could marry two wives. Note that the average age gap data takes only first marriages into account. The spousal age gap is typically higher with subsequent wives, which further increases the potential for polygyny.

Polygynous countries differ from monogamous ones along several demographic dimensions. In Table 1, I compare data of all polygynous countries with data for monogamous countries located close to the equator. There are about 60 monogamous countries close to the equator, mainly in the Caribbean, the Pacific, parts of South America, and Africa. Controlling for latitude is a way to focus on a more comparable groups of countries.[7] Alternatively, selecting monogamous countries based on GDP per capita does lead to similar numbers. In addition, Table 1 includes averages for countries within Sub-Saharan Africa that have low levels of polygyny (column 3) and data on Western Europe and North America (column 4).

The data reveal striking differences between polygynous and monogamous countries. The average age difference between husband and wife in highly polygynous 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.

[6]Another factor that helps sustain the high incidence of polygyny is widow remarriage.

[7]Most developed countries are also monogamous. However, fathers typically do not control their daughter's marriage in these countries and hence the channels emphasized in this paper do not apply.

Table 1: Polygynous vs. Monogamous Countries

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

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

$^{\flat}$ at domestic prices, $^{\natural}$ at international prices.

For data sources and precise definitions: See Appendix A.

The total fertility rate in 1980 was 6.7 on average in polygynous countries compared to only 4.5 for monogamous countries. To take differences in infant mortality into account, I compute the number of surviving children. There is still a two-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 (column 3). 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.

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 GDP in other Sub-Saharan African countries, and only 40% of GDP in 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. Since the relative price of investment goods is higher in poor than in rich countries, the nominal savings rates (total savings as a percentage of gross national product at national prices) might be a better measure of savings for the purpose of this paper. 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

In some cultures payments and gifts are made in both directions.[8] 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).

It might seem puzzling that in some countries brides have a positive price while in others their price is negative. Anthropologists and ethnographers have pointed out a strong correlation between the marriage law and the sign of the brideprice. Murdock's *Ethnographic Atlas* systematically categorizes information on marriage customs for roughly 1,000 societies (Murdock 1986). Hartung (1982) uses these data to study the correlation of marriage payments with polygyny. He finds that 91% of polygynous societies where more than 20% of all married men are polygynous use brideprices, whereas 62.5% of all monogamous societies do *not* use brideprices. Botticini and Siow (2003) report the use of

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

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 are available, 7 are reported to use dowries as the predominant marriage payment.[9]

Unfortunately, no comprehensive cross-country data regarding the use of marriage payments are available for the 20th century. Therefore I have reviewed individual country reports written by anthropologists and ethnographers for each of the countries with high levels of polygyny in Appendix A. My finding is that brideprices are used in all countries listed in Appendix A, with the exception of Bangladesh that has experienced a recent transition from brideprice to dowry payments. While more and better data would be desirable, the available evidence seems to suggest a high correlation between polygyny and the use of brideprices, on the one hand, and between monogamy and dowries, on the other hand.

2.2 Family Life in Sub-Saharan Africa

Most cultures South of the Sahara are patrilineal and patrilocal, which means that family life is centered around the lineage as defined through male descendants and that upon marriage women move to where their husband's family is located. Like in many traditional societies, power in these families lies in the hands of the old and the male (Caldwell 1978). This means that men make most decisions and also that older men do not work much.[10]

The purpose of marriage in Sub-Saharan Africa is reproduction. Marriage is defined as the transfer of a woman's reproductive rights from her father to a husband.(Caldwell (1976a), p.361, Caldwell and Caldwell (1987), p. 420).[11] In exchange for the reproductive right, the groom pays a brideprice to the father. Interestingly, fathers frequently do not help their sons pay a brideprice for their own brides. Instead, men often use the revenue

[9]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)).

[10]Caldwell (1976a) reports that even "middle-aged men spend much of their time [...] drinking in coffee shops while their sons take over the heavier field work."

[11]This is interpreted quite literally, so that any children are regarded as the husband's legitimate offspring, irrespective of biological fatherhood. Sometimes this is carried out to the extreme, where fatherhood is attributed to the husband even after his death (Caldwell, Caldwell, and Orubuloye 1992).

from a daughter's marriage to buy additional wives for themselves,[12] while sons marry late to give them time to accumulate enough wealth to afford a wife.

Traditional belief systems in Sub-Saharan Africa put great emphasis on the succession of generations, which manifests itself in an extreme fear of dying without children (Caldwell and Caldwell 1987). Since a man acquires reproductive rights, he typically makes all fertility decisions. Men prefer to marry women who are significantly younger because this will make her more submissive and accept his decisions. Interestingly, while women have little say in the fertility decision, they do bear a big part of the costs. As Caldwell and Caldwell (1987) reports, "the day-to-day care of children, and to a large extent their economic support, is mostly the responsibility of their mother." Indeed, women and her children often constitute a separate economic unit (Caldwell (1976b), p. 328)). Especially in West Africa, women are likely to earn their own incomes by trading (Caldwell, Caldwell, and Orubuloye 1992). Typically men and women also remain spatially separate, and each wife might have her own hut within a larger complex (Quale (1992), p. 238). For example, survey results from Nigeria in 1973 show that "fewer than one-third of wives normally eat with their husbands or sit together on occasion" (Caldwell 1976a).

Another characteristic is that a woman's rights are severely restricted unless she is attached to a man, that is, a father, husband, or son. For example, Caldwell, Caldwell, and Orubuloye (1992) report that wives farm on land that belongs to their husbands' lineages and have no right to any land of their own. Practically, this means that an unmarried woman has difficulties earning her livelihood after her father's death. Even before a patriarch's death, there is no clearly defined role for unmarried daughters in most traditional families, and hence they are considered costly (Caldwell (1976b), p. 330).

3 The Model

I analyze an infinite-horizon, overlapping generations model. People differ by age and gender, but there is no further heterogeneity. Abstracting from further heterogeneity

[12] See Quale (1988), page 91, Goody and Tambiah (1973), page 8.

keeps the model tractable and allows me to focus on the main mechanism.[13] People 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. People derive utility from consumption in both adult periods of their lives and from the total number of children, f_t. The utility function is given by $\ln(c_t^y)+\beta\ln(c_t^o)+\gamma\ln(f_t)$, where β is the discount factor and γ captures how much a person cares about the number of children.

There are men and women in this economy. In order to have children, people need to be married and both spouses have to be fecund. I assume that women are only fecund during young adulthood, while men are fecund during both adult periods.[14] This makes the timing of births over the life cycle of a man endogenous in the model. Let f_t^y denote the number of children he has when young and f_{t+1}^o the number of children he has when old. Then $f+t = f_t^y + f_{t+1}^o$. Note that children born at different ages enter the utility function in exactly the same way. This is meant to capture the emphasis on lineage survival in Sub-Saharan African cultures. Since the reward for having a large family is "approval in this world and beyond," rather than the utility benefit from spending time with one's children, the timing of births is irrelevant.[15] This is not unlike the goal of genetic survival that is emphasized in the demographic biology literature. It should be added that this assumption is not innocuous. It does play a major role in the analysis because it implicitly introduces a male preference for late marriage. Alternatively one could explicitly model a preference for wives who are younger, as seems plausible, which would lead to similar results.

There is a decentralized marriage market in which men trade reproductive rights in women. Since women are only fecund as young adults, there is only a market for young adult women.[16] Let p_t denote the price of a bride at time t. The potential buyers in the bride market are adult men of both ages. Let n_t^y and n_{t+1}^o denote the number of brides a man acquires when he is young and old respectively. The sellers in the bride market are fathers who arrange marriages for their daughters. A man is fecund in both periods

[13]Typically richer men are more likely to be polygynous, an empirical regularity I cannot address here. Gould, Moav, and Simhon (2004) and Lagerloef (2004) model heterogeneity in male skills explicitly.

[14]Siow (1998) analyzes how differential fecundity affects gender roles in monogamous unions.

[15]See Caldwell and Caldwell (1987), who discuss the religious belief system and its effect on fertility.

[16]I abstract from child betrothal, which can be interpreted as a future of a marriage contract, since I am more interested in the spousal age gap than the actual age at marriage.

of his life, but it takes a period for a daughter to become fecund, thus, a father will sell his daughters either when he is old or arrange the marriage for after his death. Let d_t^y be the number of daughters given into marriage when he is old and d_t^o the number of daughters that consummate marriage after his death.

An object of interest will be the sign of the brideprice, p_t. The price will be determined by the supply and demand of brides. If the number of women of marriage age exceeds demand for brides, one would expect the price to be negative. Note, however, that in the framework so far, the price could never possibly be negative, instead, fathers would simply not marry their daughters.[17] In such a framework, a positive equilibrium brideprice would not be very interesting, since the set-up would force it to be non-negative. However, we do observe marriage payments from fathers to sons-in-law in many traditional societies, i.e. fathers are often willing to marry their daughters even at a cost.[18] There are several social and economic costs associated with having unmarried daughters, ranging from having to support her, the daughter's unhappiness, the cost of protecting her virginity, the fact that she would never bear (legitimate) grand-children, to her being without a protector after the father dies (since she would also be husband- and son-less) and therefore not having access to land and property. To keep the model tractable, I do not model all of these costs explicitly. Instead, I assume a cost, a, per daughter who remains unmarried after the father's death.[19]

Having children is costly for both fathers and mothers. I assume that if one woman has f_t children, the total cost is $2\epsilon f_t^2$ and that this is shared equally between husband and wife. This convex cost function captures the impossibility for one woman to have an infinite number of children. It can also be interpreted as additional children taxing a woman's health by increasing amounts.[20] In Tertilt (2003) I show that most of the results carry through for a general convex cost function. The assumption of equal cost sharing implies that an age i polygynous man with n_t^i fertile wives and f_t^i new children, i.e. with $\frac{f_t^i}{n_t^i}$ children per wife, will pay a total cost of $\epsilon(\frac{f_t^i}{n_t^i})^2 n_t^i = \epsilon\frac{{f_t^i}^2}{n_t^i}$. For a man the

[17]Of course daughters would be willing to pay for marriage, since they need a husband for reproduction, but it is assumed that a marriages can only be arranged by fathers, not women themselves.

[18]The argument that children's marriages are important for their parents is also made in Zhang (1994).

[19]A utility cost for unmarried daughters leads to essentially the same results.

[20]One might argue that there is a range of increasing returns to scale in child production. Since biologically there is a maximum number of children a woman can bear, increasing returns cannot be true in the limit. Hence, while the cost function might be s-shaped, it has to be convex in the limit.

per child cost falls if he has more wives. From a man's perspective, this is equivalent to a simple constant returns to scale production technology with wives and consumption goods as inputs and children as output.[21] I assume that half the children are male, and half are female.[22] The choice problem of a man can now be summarized as[23]

$$\begin{aligned}
&\max \ln(c^y) + \beta \ln(c^o) + \gamma \ln(f^y + f^o) \\
s.t.\quad & c^y + s^y + pn^y + \epsilon \frac{(f^y)^2}{n^y} \leq w \\
& c^o + s^o + pn^o + \epsilon \frac{(f^o)^2}{n^o} \leq +(1 + r - \delta)s^y + pd^y \\
& a(\frac{f^y + f^o}{2} - d^y - d^o) \leq (1 + r - \delta)s^o + pd^o \\
& d^y \leq \frac{f^y}{2}, \quad d^o \leq \frac{f^o}{2}, \quad c^y, c^o, d^y, d^o, f^y, f^o, n^y, n^o \geq 0
\end{aligned} \tag{1}$$

The first constraint is the budget constraint when young. The income during this period is the wage, w. Expenditures are made for consumption, the purchase of wives, and the cost of raising children. The second constraint is the budget constraint when old. Old men have no labor income, but receive returns on their savings. They can buy wives, have children and arrange marriages for their daughters. The third constraint is a budget constraint for after the man's death. This allows a man to borrow against revenues from a daughter's marriage after his death. If the brideprice was negative, then s^o can be interpreted as a "trust fund" a man sets up to ensure his daughters can marry even after his death. Alternatively, if he does not arrange a marriage for some of his daughters, then he incurs a cost a per unmarried daughter. The last two constraints ensure that a man cannot sell more daughters than the number of female children he has in the relevant period. Finally, the usual non-negativity constraints apply. Note that there are no restrictions on s^y and s^o, i.e. there are no borrowing constraints.

Women

Women have the same utility function and the same endowments as men, but make less choices. Her reproductive rights are sold by her father and she obeys her husband's fertility decisions. She does incur a cost $\epsilon \bar{f}^2$ to bear $\bar{f}$ children. If she does not have a husband, she cannot bear children. Note that in a polygynous marriage, the number

[21]The corresponding production function is $f = \sqrt{\frac{ng}{\epsilon}}$, where g is the consumption good input.

[22]Edlund (1999) analyzes endogenous sex choice. This is of limited relevance for the questions addressed here because empirical sex ratios deviate no more than 8% from one (World Bank 2003).

[23]Time subscripts are suppressed for ease of exposition.

of children for a husband is the sum of the children with each of his wives. Since it is optimal for a man to have the same number of children with each wife in a given period, it follows that fertility of husband and wife are related by $\bar{f} = \frac{f^i}{n^i}$, where $i = y, o$ is the age of her husband. Taking her fertility $\bar{f}$ as exogenous, a woman solves[24]

$$\begin{aligned} \max_{c_f^y, c_f^o, s_f} \quad & \ln(c_f^y) + \beta \ln(c_f^o) + \gamma \ln(\bar{f}) \\ s.t. \quad & c_f^y + s_f + \epsilon \bar{f}^2 \leq w \\ & c_f^o \leq (1 + r - \delta) s_f \end{aligned} \tag{2}$$

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: $n^y + n^o \leq 1$. The woman's problem is exactly the same as (2).

3.1 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

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

3.2 Production

There is an aggregate technology that uses capital and labor to produce the consumption good. I assume a standard Cobb-Douglas production function, $Y_t = A K_t^\alpha L_t^{1-\alpha}$. 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/borrow when young and old, while women save only when young. Hence, $K_{t+1} = (s^y + s_f) M_t + s^o M_{t-1}$.

[24] The problem of an unmarried women is the same but with $\bar{f} = 0$.

On a balanced growth path the capital-output ratio stays constant. Dividing by Y_t, the capital-output ratio can be written as

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

The expression shows that differences in the capital output ratio between polygynous and monogamous countries may come through two different channels, differences in saving rates and differences in the population growth rate.

Output per capita is different from output per worker because children and old people do not work. The relationship between output per worker and output per capita depends on the population growth rate. 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 $\frac{Y}{L} = A^{\frac{1}{1-\alpha}}(\frac{K}{Y})^{\frac{\alpha}{1-\alpha}}$. Faster growing populations have lower output per capita, holding all else equal.

3.3 Definition of Equilibrium

I focus on balanced growth path equilibria. Aggregate variables will be growing on such a balanced growth path due to endogenous population growth, while per capita variables will all be constant.

In addition to optimizing behavior and the usual market clearing conditions, there is a marriage market clearing condition. The supply of brides depends on the number of marriages fathers want to arrange for their daughters. Aggregate supply of brides in t is $d_t^y M_{t-1} + d_t^o M_{t-2}$. Aggregate demand will come from young and old men and is equal to $n_t^y M_t + n_t^o M_{t-1}$. On the balanced growth path, marriage market clearing simplifies to

$$d^y \eta + d^o = n^y \eta^2 + n^o \eta \ . \tag{5}$$

Definition 1 *A balanced growth path (BGP) 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 $n = (n^y, n^o)$, numbers of children $f = (f^y, f^o)$, and numbers of daughters sold $d = (d^y, d^o)$, prices (p, r, w), a population growth factor η and a capital-output ratio $\frac{K}{Y}$ such that*

- *given prices, $(c^y, c^o, s^y, s^o, n, f, d)$ solves the man's problem (1);*

- *taking prices and* $(\bar{f}, d)$ *as given,* (c_f^y, c_f^o, s_f) *solves the woman's problem (2), where* $\bar{f}$ *is fertility per wife decided by her husband;*

- *population dynamics evolves according to (3);*

- $\frac{K}{Y}$ *is given by (4);*

- *the market for brides clears (5);*

- *profit maximization holds:* $r = \frac{\alpha}{\frac{K}{Y}}$ *and* $w = (1-\alpha)A^{\frac{1}{1-\alpha}}\frac{K}{Y}^{\frac{\alpha}{1-\alpha}}$.

The 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: $n^y + n^o \leq 1$.

4 Characterizing the Balanced Growth Path

Whether polygyny is allowed matters both qualitatively and quantitatively. In this section, I characterize the BGPs under polygyny and monogamy.[25] 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. The entire model cannot be solved analytically, thus I will present numerical results in Section 5.[26] Before turning to the general equilibrium analysis, I will first briefly discuss the optimal timing of marriage and procreation, given prices.

4.1 Optimal Timing of Marriage and Child Birth

Women are fecund only during one period, which implies that for a man the marriage age and the age at procreation are not two separate decisions. Further, I have assumed that men are indifferent about the timing of births from a utility perspective. However, the costs of marriage and procreation are affected by their timing. The optimal choice

[25]The proof of equilibrium existence is omitted as there are no non-convexities or discontinuities which could makes existence a problem. However, for some parameter values no balanced growth path exists. I discuss existence of a BGP for a very similar model in Tertilt (2003).

[26]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.

for a man is to marry and have children whenever it is cheaper in discounted terms. If marriage and children involved only costs, and the interest rate was positive, then obviously it would be better to postpone these costs. However, marriage may be a net benefit (if the price is negative) and children may yield revenues when they are sold. The relevant consideration thus involves a comparison of these overall costs and benefits, which depend on several factors including the brideprice and the desired number of children. A closer look at the budget constraints illustrates this point. Combining the three constraints into one intertemporal budget constraint yields[27]

$$c^y + \frac{c^o}{1-\delta+r} \leq w + n^y[\frac{p\frac{f^y}{2n^y}}{1-\delta+r} - p - \epsilon(\frac{f^y}{n^y})^2] + \frac{n^o}{1+r-\delta}[\frac{p\frac{f^o}{2n^o}}{1-\delta+r} - p - \epsilon(\frac{f^o}{n^o})^2] \quad (6)$$

From the budget constraint it is obvious that a man would never choose to marry during both periods in his life. Equation (6) also shows that if

$$\left[\frac{p\frac{f^i}{2n^i}}{1-\delta+r} - p - \epsilon(\frac{f^i}{n^i})^2\right] > 0 \quad (7)$$

and n^i was unconstrained, then a man could make an infinite profit by holding the number of children per wife, $\frac{f^i}{n^i}$, constant and marrying an infinite number of wives. This obviously cannot be an equilibrium, and hence the expression will be negative whenever polygyny is allowed. A negative term means that, including the cost of child-rearing, marriage constitute a net cost. Given a positive interest rate, a man prefers to postpone this cost. Thus, a polygynous man will optimally choose $n^o > 0$ and $n^y = 0$ as long as $1 + r - \delta > 1$.

In the monogamous economy, n is constrained to be equal to one, therefore $p[\frac{\frac{f^i}{2}}{1-\delta+r} - 1] - \epsilon(f^i)^2 > 0$ is possible, which would induce a man to marry when young when $r - \delta > 0$. This possibility arises when brideprices are negative and fertility is not more than $2(1 + r - \delta)$. On the other hand, a positive brideprice may also be consistent with the expression being positive as long as desired fertility is high enough.

[27]This expression assumes all daughters are sold at price p. This is without loss of generality since not selling a daughter will only be optimal if $p = -a$, which implies that single and married daughters enter the budget constraint symmetrically at the equilibrium prices.

4.2 Polygyny

Proposition 1 *If polygyny is allowed, then any BGP with a positive net interest rate* $(r - \delta > 0)$ *has the following characteristics.*[28]

1. *The brideprice is strictly positive,* $p > 0$.

2. *Men marry and have children when old* $(n^y = 0, n^o > 0, f^y = 0, f^o > 0)$.

3. *All daughters marry,* $d^y = 0, d^o = \frac{f^o}{2}$.

Proof. Part 1 is very intuitive. Suppose $p_t \leq 0$ 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. Part 2 follows directly from the discussion in Section 4.1. Finally, given a positive brideprice, it is optimal for a man to sell all his daughters. This together with part 2, proves part 3. □

Using Proposition 1, it is 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 brides (5) together with the population growth factor gives the number of wives $n^o = \sqrt{\frac{f}{2}}$. Therefore as long as women have at least two children, polygyny happens in equilibrium despite a balanced sex ratio and a homogenous population.[29] Polygyny is feasible because of a growing population and spousal age gaps. Finally, the total fertility rate is $\frac{f}{n^o} = \sqrt{2f}$. Using these results, the man's problem simplifies to

$$\begin{aligned} &\max_{c,f,n,s} \ln(c^y) + \beta \ln(c^o) + \gamma \ln(f) \\ &s.t. \quad c^y + s + pn \leq w \\ &\qquad c^o + \epsilon \frac{f^2}{n} \leq (1 - \delta + r)s + p\frac{f}{2} \ . \end{aligned} \tag{8}$$

[28]Given the rarity of negative real interest rates, the focus on BGPs with positive interest rates seems fairly innocuous. Moreover, I have not been able to construct numerical examples where the interest rate is indeed negative, but it remains a theoretical possibility.

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

The first order conditions of this problem are[30]

$$
\begin{aligned}
f: \quad & \frac{\gamma}{f} + \frac{p\beta}{2c^o} &= \frac{\beta}{c^o} 2\epsilon \frac{f}{n} \qquad (9) \\
n: \quad & \frac{p}{c^y} &= \beta \frac{1}{c^o} \epsilon (\frac{f}{n})^2 \qquad (10) \\
s: \quad & \frac{1}{c^y} &= \frac{\beta}{c^o}(1 - \delta + r) \quad . \qquad (11)
\end{aligned}
$$

Equation (9) equates the marginal costs and benefits 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 (10) 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 (11) compares the marginal utility from consuming when young to the discounted marginal utility from consumption when old.

4.3 Monogamy

The predictions for monogamy are more varied. For example, if the parameters in the polygynous model are such that population growth is exactly 1, then the equilibrium number of wives is also one and monogamy arises endogenously. For this special case it is irrelevant whether polygyny is allowed or not. This is not a very interesting case, since population growth is positive in almost all developing countries. To exclude this uninteresting case, I focus on parameters that imply positive population growth, that is, γ is high enough and ϵ low enough so that the total fertility rate is higher than 2.[31] Even ruling out this case, depending on parameters, three different things can happen.[32]

Proposition 2 *Depending on parameters, a balanced growth path with $\eta > 1$ and $r - \delta > 0$ is of one of the following three types.*

1. *If a is small, then the BGP is characterized by a negative brideprice, $p = -a$, a spousal age gap, and some women remaining single.*

[30] The first order conditions are necessary and sufficient. A simple redefinition of variables shows that this is a convex problem. I provide details in Tertilt (2003).

[31] Of course, fertility is an endogenous variable. Identifying conditions on parameters that guarantee an equilibrium total fertility rate of more than 2 is difficult since no analytical solution for fertility exists. However, there are many examples that satisfy this assumption.

[32] The exact range of parameters for each case can only be determined numerically, see footnote 31.

2. *If a is large, ϵ not too low and γ not too high, then the BGP is characterized by a negative brideprice, $0 < p < -a$, no spousal age gap, and all daughters marrying.*

3. *If a is large and ϵ is very low/and or γ very high, then the BGP is characterized by a positive brideprice $p > 0$, no spousal age gap, all daughters marrying, and $f > 4(1 + r - \delta)$.*

Proof. Given that we consider only BGPs with positive population growth, different generations are of different sizes. Thus, if there is an age gap in marriage then some women will remain single. This can only happen in equilibrium if fathers are indifferent between marrying their daughters or not, i.e. if $p = -a$. This is case 1. However, this is only an equilibrium if at this price men actually (weakly) prefer to marry a younger spouse. Depending on the size of a this might not be the case. It follows from the discussion in Section 4.1 (see equation (6)) and the assumption $r - \delta > 0$ that a man prefers a younger spouse if

$$\epsilon f^2 + p[1 - \frac{f}{2(1 + r - \delta)}] > 0 \tag{12}$$

As a is increases, this condition will eventually be violated.[33] Then men will prefer to marry someone their own age instead. But then there are no single women and fathers are not willing to pay $p = -a$. In this case, the equilibrium will involve no spousal age gap, no single women and men are exactly indifferent between marrying when young and when old. Whether such an indifference can be achieved with a negative or positive price depends on the optimal fertility decision. If desired fertility is not too high (i.e. $f < 2(1 + r - \delta)$) then there is a negative brideprice that makes the expression negative and thereby assures an equilibrium with no spousal age gap. This happens when ϵ is high enough and/or γ is low enough such that desired fertility is not too high relative to the interest rate. This is case 2. For higher γ and/or lower ϵ, a positive brideprice may result in equilibrium. For this to be optimal, rearranging equation (12), the following must hold

$$p > \frac{2\epsilon f^2(1 + r - \delta)}{f - 2(1 + r - \delta)} \tag{13}$$

For this to be an equilibrium, the first order conditions must hold, which puts another restriction on the brideprice. Assuming marriage when young, the first order condition

[33] $f \to 0$ as $a \to \infty$, so clearly (12) cannot hold in the limit at $p = -a$.

with respect to fertility is[34]

$$\frac{\gamma}{f} = \frac{1}{c^y}[2\epsilon f - \frac{p}{2(1+r-\delta)}] \tag{14}$$

This puts a upper bound on p since the right hand side has to be positive. The upper bound is

$$p < 4\epsilon f(1+r-\delta) \tag{15}$$

Equations (13) and (15) can hold simultaneously only if $f > 4(1+r-\delta)$. This is case 3. For such a high level of fertility to be optimal in equilibrium, the desire to have children must be high enough (γ) or the cost must be low enough (ϵ). □

Proposition 2 shows that monogamy is often characterized by negative brideprices. The intuition is that the no-polygyny constraint limits the demand for brides, which can result in an excess of marriageable women due to population growth and the male preference for younger spouses.[35] Single women are costly to her father and hence, fathers are willing to pay a dowry for a daughter's marriage. The prospect of a dowry may then persuade a man to marry a wife of his own age (case 2). If the costs of single daughters is very low, then fathers are not willing to pay enough to persuade the prospective grooms and hence an equilibrium with singles results (case 1). Finally, case 3 shows that a positive brideprice can also be consistent with monogamy. This can happen only if desired fertility is very high. For example, with an annual net interest rate of 3% and a period length of 15 years, case 3 would only be relevant for countries with 6.2 or more children per women. Many monogamous countries (e.g. India, Bangladesh, several European countries) have experienced a transition from brideprice to dowry systems, as well as declines in fertility.[36] Assuming that some exogenous factor caused the decline in fertility (e.g. an increase in the cost of child-rearing), then this switch from brideprice to dowry is consistent with the model.

It should be emphasized that the one-wife constraint is always binding in equilibrium. This is easy to see. Consider cases 1 and 2 first. Additional wives do not impose any cost on a man (indeed they come with a transfer) and strictly lower the cost of child-rearing.

[34]This first order condition can be derived from maximizing a man's utility subject to (6).

[35]The preference for younger spouses is generated endogenously through their ability to create children at a lower cost. The way children enter the utility function is crucial for this result. This could be relaxed, if one assumed a preference for younger wives explicitly.

[36]The switch from brideprice to dowry is documented by Caldwell, Reddy, and Caldwell (1983) for India, by Lindenbaum (1981) for Bangladesh and by Hughes (1978) for Mediterranean Europe.

Thus a man would always prefer to have more wives. For case 3 (and 2 as well), the proof of Proposition 2 shows that $\left[\frac{p\frac{f}{2}}{1-\delta+r} - p - \epsilon f^2\right] > 0$ holds. But then a man could increase income by marrying a second wife and holding fertility per wife constant as can be seen from the budget constraint, equation (6). Thus monogamy cannot be generated endogenously in this model, except of course when population size is constant.

It should be stressed that the three different cases from Proposition 2 do not constitute a multiplicity of equilibria, instead, different parameter combinations will lead to different outcomes. Which case is relevant is ultimately an empirical question. There is however also a multiplicity of brideprices within cases 2 and 3. For example, in case 2, any price between $-a$ and the one that makes men indifferent between $n^y = 1$ and $n^o = 1$ is also an equilibrium price. 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 no heterogeneity, the indeterminacy is considerably reduced. In particular, Proposition 2 shows that the sign of the brideprice is determined by parameters. The reason is that the endogenous timing of marriage makes the demand curve less flat.

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 is to evaluate what would happen to a polygynous country if a marriage law requiring monogamy was introduced. To do this, I calibrate the polygynous BGP to the "average polygynous country" (see Table 1). I then compute the monogamous BGP using the same parameters and compare the two BGPs.

Note that the cost of single women, a, cancels out of the polygynous equilibrium and therefore cannot be calibrated. If a is high, then all daughters will marry in the monogamous equilibrium and the magnitude of a is irrelevant. If a is low (case 1), then a fraction of women remains single. I consider a high cost, a, to be the relevant case for the quantitative exercise, as marriage rates are close to 100% in all developing countries and almost always higher for women than for men.[37] Thus, the results in this section are based on the assumption that a is high enough for case 1 not to be the equilibrium.[38]

Proposition 2 also showed that both positive and negative brideprices are consistent with monogamy, but that this depends on parameters. Given parameters, it can be checked numerically whether case 2 or 3 is indeed an equilibrium. It turns out that the calibrated parameters fall in the range of case 2. The equilibrium conditions for this case are summarized in Appendix B.

Finally, as discussed in Section 4.3, even within case 2, there is a multiplicity in the equilibrium dowry. For the numerical results, I assume that the dowry is such that it makes men exactly indifferent between n^y and n^o. Other monogamous equilibria involve higher dowries, which makes children even more costly and hence decreases the incentives to have children even more. Therefore, the numerical results give a lower bound on the savings rate and an upper bound on the fertility rate under monogamy. In other words, the comparison between the polygynous and the monogamous economy would be even starker if one considered any of the other equilibria.

5.1 Calibrating the Polygynous Economy

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 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, $1,029. The annual discount factor is set equal to 0.95 in line with

[37] See UN Population Division (2000).

[38] Moreover, the equilibrium of case 1 is arguably not very stable, as single women would have a strong desire to pay for their own marriages, which is ruled out by the assumption of complete paternal control.

the macro literature. Annual depreciation of 7% corresponds to $\delta = 1 - (1 - 0.07)^{15} = 0.66$. 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 2 summarizes the calibration.

5.2 Results

Table 3 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 magnitudes predicted by the model compare well to the data.[39] 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 2.4 times the polygynous output, while in the data it is 2.5 times as high. These results are fairly robust; see Appendix C.

Table 4 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 weakness is partly due to the limited number of periods, and partly due

[39]As stressed in the introduction, I focus on differences in marriage law and abstract from all other differences across these two groups of countries. I therefore interpret my results more as indicating what would happen in SSA if monogamy was enforced, rather than as an explanation for cross-country differences.

Table 2: Calibration

Parameter	Value	matched to fit
γ	0.39	surviving number of children = 5.04
β	0.46	annual discount factor = 0.95
ϵ	32.3	$\frac{S}{Y} = 14\%$
A	437	GDP p.c. normalized to 1,029
α	0.4	income share of capital = 40%
δ	0.66	7% annual depreciation

Table 3: Numerical Results

	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

Table 4: 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	20.3%		3.5%	
Total marriage payments/GDP	10.2%		9.8%	
Male utility	12.00		12.44	
Female utility	11.38		12.22	

to abstracting from mortality. However, the model is able to replicate the demographic differences qualitatively. 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 4, which would also lower the average number of wives.[40]

Table 4 also reports the size of marriage payments and the total amount of resources spent on child-rearing in the model. In both cases, marriage payments amount to roughly 10% of GDP. The table also shows that total expenditures on children are much higher

[40] Appendix C shows results for a calibration to a lower surviving fertility rate.

under polygyny than under monogamy. In fact, 20.3% of GDP is spent on producing children in the polygynous economy, while only 3.5% of resources are devoted to child production in the monogamous economy. The reason for this large difference is partly due to the higher fertility in the polygynous economy and partly due to a higher average child cos. 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.

Finally, Table 4 shows that steady state utility for both men and women is higher under monogamy than polygyny. However, this does not necessarily imply polygyny is inefficient. The steady state comparison ignores utility along the transition and therefore no conclusions about dynamic inefficiency can be drawn. Moreover, the concept of Pareto efficiency is not well-defined in the context of endogenous fertility models[41]

Note that the polygynous equilibrium is similar to an overlapping generations model with a pay-as-you-go social security system, where the old age pension is set such that the equilibrium capital stock is below the Golden Rule. To see the analogy, simply interpret the payments that young men make to old men in form of brideprices as social security transfers. Of course the analogy is not perfect as the amount of the transfers is endogenous here, while it would be exogenous in a model with social security.

6 Conclusion

In this paper I analyze the macroeconomic consequences of allowing men to marry multiple wives. I find that banning polygyny has large effects along several dimensions. The increased demand for wives created by allowing polygyny always means that the value of a brides is strictly positive, while it may be negative when men are restricted to marrying one wife. The assumption that fathers may buy and sell daughters, but not sons, means that a positive brideprice makes children a much better investment than when the price is negative. Therefore, polygyny leads to high fertility and partially crowds out investment in physical assets. Low investment and high population growth both contribute to a lower capital-output ratio, and thereby to lower output per capita. I show that for reasonable parameter values enforcing monogamy reduces fertility by 40%, increases

[41] In Golosov, Jones, and Tertilt (2004), we propose several alternative efficiency concepts that can be used in models with endogenous fertility.

savings by 35% and raises output per person by 140%. This suggests that although the practice of polygyny is certainly not the sole cause of poverty it might be an important contributing factor for the continuing underdevelopment of Sub-Saharan Africa.

It might be difficult to enforce a marriage law that prescribes monogamy. Several countries have introduced such laws without much effect on the actual marriage behavior. An alternative policy often proposed by development institutions like the World Bank is to give more rights to women. Allowing women to make their own marriage decisions would significantly reduce the return on wives for men. Thus, such a policy should also increase the incentive to invest in physical assets. Results not reported here show 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. This shows that a smaller increase in living standards might be achievable without a change in the marriage law.

Another interesting extension would be to see how the analysis extends to family altruism in the sense of Barro and Becker (1989). Altruistic parents would take the trade-off between quantity and quality of children into account. Altruism could potentially induce parents to have fewer children and save more, leading to a higher capital stock and higher wages for the children. It is unclear how important this effect would be quantitatively. The effect of altruism on savings would be present in both family arrangements, so that the quantitative *differences* between the two environments might not change much.

This paper leaves several open questions. I explain differences in output per capita between polygynous and monogamous countries solely through differences in measurable inputs: differences in the capital output ratio and differences in the worker population ratio. It is of course well-established that differences in physical and human capital can only partially explain the variation in output per capita across countries (e.g. Hall and Jones (1999)). A large part of the variation is instead due to differences in total factor productivity (TFP). Why TFP differs so widely across countries is an important open question which cannot be addressed in the framework of this paper. Secondly, this framework implies large cross-country differences in the returns to capital, which we do not seem to observe. It also begs the question why capital would not flow to the country with the higher return. To address these questions one would need to depart from the closed economy analysis used in this paper.

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A Data Appendix

Table 5 includes all countries where more than 10% of married men have multiple wives.[42]

Table 5: 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

· indicates no data available

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

Data Definitions:

Sex ratio: Percentage of the population that is female.

Polygyny 1: % of married men in polygynous union (both legal marriages and cohabiting unions).

Polygyny 2: Average number of wives per married men.

Price: B=Brideprice, D=Dowry.

TFR (total fertility rate): The estimated number of children per woman over her life-cycle using current

[42] 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.

age-specific live birth rates, 1980.

IMR (infant mortality rate): Number of live births per 1000 that die before the first birth day, 1980.

CMR (child mortality rate): 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. (Marr1 and Marr2 include consensual unions in some countries. See UN Population Division (2000) for a detailed description.)

A.1 Data Sources

Data on polygyny is from the United Nations (1990) and from Bankole and Singh (1998), for each country I use the latest year of data available. 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 Bureau (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 (see Summers and Heston (1991)).

B Monogamous Equilibrium (Case 2)

Assuming that a is high enough that it is optimal to marry all daughters, the problem of a man who marries young can be written as

$$V^y(p) = \max_{c^y, c^o, f} \ln(c^y) + \beta \ln(c^o) + \gamma \ln(f)$$

$$\text{s.t.} \quad c^y + \frac{c^o}{1-\delta+r} + \epsilon f^2 \leq w - p\left(1 - \frac{\frac{f}{2}}{1-\delta+r}\right)$$

The problem of a man who marries old is

$$V^o(p) = \max_{c^y, c^o, f} \ln(c^y) + \beta \ln(c^o) + \gamma \ln(f)$$

$$\text{s.t.} \quad c^y + \frac{c^o}{1-\delta+r} + \frac{\epsilon f^2}{1-\delta+r} \leq w - \frac{p^w}{1-\delta+r}\left(1 - \frac{\frac{f}{2}}{1-\delta+r}\right)$$

Considering an equilibrium of case 2, the first order conditions of the first problem are the relevant ones for fertility and consumption decisions. These are

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

For $n^y = 1, n^o = 0$ to be optimal, we need in addition that a man prefers to be married when young. This gives the condition that determines the equilibrium brideprice:

$$V^y(p) \geq V^o(p) \quad .$$

The remaining equilibrium conditions are straightforward. The saving rates follow immediately from the budget constraints: $s^y = w - p - \epsilon f^2 - c^y$ and $s^o = 0$. The population growth rate is $\eta = \frac{1}{2}f$. Wage, interest rate and capital output ratio are exactly as described in section 3.

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 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 6. 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 6 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.

Table 6: 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