Polygyny, Fertility, and Savings

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Sub-Saharan Africa has a high incidence of polygyny. It is also the poorest region of the world. In this paper I ask whether banning polygyny could play any role for development. Using a quantitative model of polygyny, I find that enforcing monogamy lowers fertility, shrinks the spousal age gap, and reverses the direction of marriage payments. Polygyny leads to high bride-prices to "ration" women, which makes buying wives and selling daughters a good investment, thus crowding out investment in physical assets. For reasonable parameter values, I find that banning polygyny decreases fertility by 40 percent, increases savings by 70 percent, and increases output per capita by 170 percent.

I. 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

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[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 either a man having several wives (polygyny) or a woman having several husbands (polyandry).

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lack of development in the region. I shall 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. For example, in Cameroon, more than 50 percent of all men have multiple wives. In fact, United Nations data show that 28 countries within this region have polygyny rates of more than 10 percent. The high polygyny rates indicate that polygyny in sub-Saharan Africa 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, 5.1 years earlier and have 2.2 children more than women in monogamous countries. The average age difference between husband and wife is 6.4 years, compared to only 2.8 years 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, and 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, e.g., Acemoglu, Johnson, and Robinson 2001). This paper does not try to disentangle the importance of each of these factors. Instead, I ask 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.

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 asymmetry means that a father gets to keep any marriage payments made for his daughters, whereas a son makes his own marriage arrangements and pays or receives his own marriage payments. An equilibrium with polygyny requires a positive bride-price to ration women, which 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 because of 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 bride-price) typically evolves in equilibrium. One crucial assumption needed for this result is men's preference for brides who are younger than they are. 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 his daughter's 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 who 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 sub-Saharan Africa. I 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 13 percent to 22 percent. A higher capital stock and lower population growth rate cause output per capita to go up by 170 percent.

The economic analysis of 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

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

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 and a daughter can have, which, if men care about the number of grandchildren they have, 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. Gould, Moav, and Simhon (2004) and Lagerloef (2005) 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 argues that men in primitive societies are very unequal, which allows rich men to marry more wives. Rich men then have more children, which dilutes their wealth over time. This makes society more equal, which in his model eventually eliminates polygyny. 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 are accompanied by economic growth. Gould et al. provide an explanation for the transition to monogamy that is similar, but they do 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 quality rather than the quantity of wives and thereby eventually eliminates polygyny. 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, inducing 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 that the marriage market may not be the

[4] Returns to human capital are also endogenous in Lagerloef (2005), which assumes an externality in knowledge acquisition.

only determinant of dowry payments. As was first pointed out by Zhang (1994), there may also be a bequest motive for dowries that cannot be entirely separated from the marriage market role. The inheritance role of dowries has been analyzed by Edlund (2001) and Botticini and Siow (2003), among others (see also Zhang and Chan 1999; Brown 2002). Finally, Anderson (2003) analyzes the importance of caste as a determinant of dowry payments.

This work leaves several challenging questions for future research. I explain differences in output per capita between polygynous and monogamous countries solely through differences in measurable inputs (investment rates and population growth rates). It is well established, however, 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 that is outside the scope of this paper.[5] Moreover, my analysis implies large cross-country differences in the returns to capital (which do not seem to be observed) without explaining why capital does not flow to the country with the higher return. To address these questions, one would need to depart from the closed-economy analysis employed here. The scope of this paper is more modest. One does observe some differences in savings and fertility rates across countries, which I argue can be a rational response to differences in marriage law. Further, the assumption that capital cannot flow across borders in response to differences in returns might not be such a bad assumption for sub-Saharan African countries in which capital markets are not very well developed.

This paper is structured as follows. Section II provides an empirical background. Section III sets up the main model. The steady states under monogamy and polygyny are characterized in Section IV. Section V outlines the calibration and the quantitative results, and Section VI presents conclusions.

II. Empirical Background

In this section, I give some background on marriage institutions in sub-Saharan Africa. I first discuss the prevalence of polygyny and show that polygynous and monogamous countries differ significantly along many economic and demographic dimensions (subsection *A*). The data provided in this section will be used to calibrate the model and to evaluate the implications of the model in Section V. A main hypothesis advanced

[5] Parente and Prescott (1999) and Herrendorf and Teixeira (2004) argue that differences in TFP can be explained to a large extent through differences in monopoly rights.

in this paper is that marriage laws affect economic outcomes through their impact on marriage payments. In subsection *B*, I show that this correlation between marriage laws and marriage payments is consistent with the available empirical evidence. In subsection *C*, I describe family life in sub-Saharan Africa in some detail. The theoretical model laid out in Section IV tries to capture the main features of these family institutions.

A. Polygyny

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. For example, in Iran, only 1 percent and in Jordan about 3.8 percent of married men have multiple wives.

Polygyny in many sub-Saharan African countries is much more widespread, with up to 50 percent of the male population in polygynous unions. It is this second group that is the focus of this paper. Appendix A provides demographic data for countries in which at least 10 percent of the male population is in a polygynous union.[6] Table A1 shows that almost all men do marry by age 50 in these countries. Thus 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 extremely high spousal age gaps coupled with high population growth (Tertilt 2004).[7] Table 1 shows that the average age gap at first marriage is almost seven years in highly polygynous countries. Annual population growth in this area is 2.7 percent, which amounts to a 20 percent increase in cohort size over seven years. On average, each man could therefore marry 1.2 wives, or, put differently, 20 percent of the population could marry two wives.[8]

The main hypothesis of this paper is that marriage laws matter. The empirical evidence is consistent with this hypothesis. In table 1, I compare data for 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

[6] Where data on percentage of men in polygynous unions are not available, I include the country either if at least 20 percent of married women are in a polygynous union or if the average number of wives per married man exceeds 1.1.

[7] Another factor that helps sustain the high incidence of polygyny is the remarriage of widows.

[8] Note also that data on the average age gap take only first marriages into account. The spousal age gap is typically higher with subsequent wives, which further increases the potential for polygyny.

TABLE 1
Polygynous vs. Monogamous Countries

	High Polygyny[a] (1)	Monogamous: |Latitude|<20 (2)	Other Sub-Saharan Africa (3)	North America/ Western Europe (4)
Number of countries	28	58	20	24
	A. Fertility and Mortality			
Total fertility rate, 1980	6.78	4.62***	5.97**	1.84***
Surviving 1 year, 1980	5.46	3.64***	4.96*	1.79***
Surviving 5 years, 1980	5.01	3.57***	4.57*	1.76***
Annual population growth, 1960–85	2.7%	2.2%***	2.5%	.8%***
Infant mortality rate, 1980	12.2%	6.9%***	11.5%	1.2%***
Child mortality rate, 1980	19.4%	11.6%***	18.3%	1.4%***
	B. Demographics			
Male age at first marriage	26.2	27.8***	26.6	29.6***
Female age at first marriage	19.9	25.0***	22.7***	27.1***
Age gap	6.4	2.8***	3.9***	2.4***
% population under 16, 1985	46	40***	44*	20***
	C. Economic Variables			
S/Y, average 1960–85 (domestic prices)	12.8	19.4**	11.0	23.0***
I/Y, average 1960–85 (international prices)	8.7	16.2***	14.3**	26.2***
K/Y, 1985	1.1	1.9***	1.6*	3.0***
GDP per capita, 1985	$975	$2,798***	$1,574*	$11,950***

Note.—For data sources and precise definitions, see App. A.
[a] See App. table A1.
* Reject the hypothesis that means are equal to col. 1 at the 10 percent level.
** Reject the hypothesis that means are equal to col. 1 at the 5 percent level.
*** Reject the hypothesis that means are equal to col. 1 at the 1 percent level.

focus on a more comparable group of countries.[9] Alternatively, selecting monogamous countries on the basis of gross domestic product per capita leads to similar numbers. Table 1 also includes averages for countries within sub-Saharan Africa that have low levels of polygyny (col. 3) and data on western Europe and North America.

The data reveal striking differences between polygynous and monogamous countries. The average age difference between husband and wife in highly polygynous countries is 6.4 years, compared to only 2.8 for the monogamous group. Women in polygynous countries marry more than five years earlier, on average, than women in monogamous coun-

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

tries. The total fertility rate in 1980 was 6.8, on average, in polygynous countries, compared to only 4.6 in monogamous countries. Taking differential infant mortality into account, I still find a two-child difference in the number of children surviving up to the age of 1. Also note that the average probabilities of dying before the first and the fifth birthdays are almost identical in the two groups of African countries. Yet again, all measures of fertility are highest in the high-polygyny region. Similarly, other demographic differences remain substantial when one compares the highly polygynous countries in sub-Saharan Africa with all other countries in sub-Saharan Africa. For example, the average age gap for a married couple is two years higher in the high-polygyny group.

Sub-Saharan African countries with a high degree of polygyny are also the poorest countries in the world. Their per capita GDP is 38 percent lower than GDP in other sub-Saharan African countries and only 35 percent of per capita GDP in monogamous countries that are 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 60 percent 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 rate (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 19.4 percent between 1960 and 1985, compared to only 12.8 percent for the polygynous group. In Section V, I shall use these data to calibrate the model and to compare the results from a policy experiment to the empirical evidence.

B. *Bride-Price and Dowry*

One of the main vehicles through which differences in marriage law can affect economic outcomes is their impact on marriage payments.[10] Anthropologists and ethnographers indeed find a strong correlation between the marriage law and the sign of the bride-price. Hartung (1982) uses data from Murdock's (1967) *Ethnographic Atlas* to study the correlation of marriage payments with polygyny for about 1,000 societies. He finds that 91 percent of countries with "general polygyny" use bride-prices, whereas 62.5 percent of all monogamous societies do *not* use

[10] In some cultures, marriage payments and gifts are made in both directions (Goody and Tambiah 1973). For the purpose of this paper, I call any net transfer coming from the groom or his family a bride-price and any net transfer from the bride's side a dowry (or negative bride-price).

bride-prices.[11] Botticini and Siow (2003) report the use of marriage payments in past civilizations. Out of six civilizations classified as polygynous, four pay a positive bride-price. Out of the nine monogamous civilizations for which data on marriage payments are available, seven have used dowries as the predominant marriage payment.[12]

Unfortunately, no comprehensive cross-country data regarding the use of marriage payments are available for the twentieth century. Therefore, I have reviewed individual country studies conducted by anthropologists and ethnographers for each of the countries with high levels of polygyny listed in Appendix A. Bride-prices are used in all these countries, with the exception of Bangladesh, which has experienced a recent transition from bride-price to dowry payments. I therefore conclude that the available evidence is in line with the main channel emphasized in this paper: marriage law affects the direction of marriage payments.

C. *Family Life in Sub-Saharan Africa*

In this subsection, I shall provide some details on how family life is organized in most of sub-Saharan Africa. In Section III, I shall then lay out a stylized model of marriage, fertility, and savings decisions that captures the main features of these family institutions.

Most cultures in sub-Saharan Africa are patrilineal and patrilocal, which means that family life is centered around the lineage as defined through male descendants and that upon marriage a woman moves to where her husband's family is located. Power in these families lies in the hands of the old and the male (Caldwell 1978). This means that men make most decisions and older men do not work much.[13]

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 (J. Caldwell 1976, 361; Caldwell and Caldwell 1987, 420).[14] In exchange for the reproductive right, the groom pays a bride-price to the father. Interestingly, fathers frequently do not help their sons pay a bride-price for their own brides. Instead, men often

[11] Here "general polygyny" means that 20 percent or more of all married men are polygynous.

[12] 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, 1391]).

[13] Caldwell (1978, 561) reports that even "middle-aged men spend much of their time . . . drinking in coffee shops while their sons take over the heavier field work."

[14] 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).

use the revenue from a daughter's marriage to buy additional wives for themselves, and sons marry late to give them time to accumulate enough wealth to afford a wife (see Goody and Tambiah 1973, 8; Quale 1988, 91).

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 at marriage, he typically makes all fertility decisions. Men prefer to marry women who are significantly younger because this will make them more submissive and more likely to accept their decisions. While women have little say in the fertility decision, they do bear a large share of the costs. As Caldwell and Caldwell report, "the day-to-day care of children, and to a large extent their economic support, is mostly the responsibility of their mother" (420). Indeed, women and their children often constitute a separate economic unit (P. Caldwell 1976, 328). Especially in West Africa, women are likely to earn their own incomes by trading (Caldwell et al. 1992). Typically men and women also remain spatially separate, and each wife might have her own hut within a larger complex (Quale 1992, 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" (J. Caldwell 1976, 367).

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 et al. (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 for the fathers (P. Caldwell 1976, 330).

III. The Model

In this section I describe a theoretical model of marriage, fertility, and savings that incorporates the following main features of family life in sub-Saharan Africa: men make most decisions, the goal of reproduction is to maximize the number of offspring, fathers sell their daughters, and unmarried daughters are costly.

I analyze an infinite-horizon, overlapping-generations model. People differ by age and sex, but there is no further heterogeneity. Abstracting from heterogeneity keeps the model tractable and allows me to focus on the main mechanism.[15] People live for three periods: as children and as young and 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 fertility. The superscripts denote consumption when young and old, respectively.

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 fecund only during young adulthood, whereas men are fecund during both adult periods; this makes the timing of births over the life cycle of a man endogenous in the model.[16] 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 survival of the lineage 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.[17] This idea is similar to the goal of genetic survival emphasized in the demographic biology literature. It should be added that this assumption is not innocuous. It plays a major role in the analysis because it implicitly introduces a male preference for late marriage. Alternatively, one could explicitly model a preference for younger wives, which would lead to similar results.

There is a decentralized marriage market in which men trade reproductive rights in women. Since women are fecund only as young adults, there is a market only for young adult women.[18] Let p_t denote the price of a bride at time t. The potential buyers in the market for brides 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 market for brides are fathers who arrange marriages for their daughters. A man is fecund in both periods of his life, but it takes a period for a daughter to become fecund; thus a father will either sell his daughters when he is old or arrange the marriage for after his death. Let

[15] Typically, richer men are more likely to be polygynous, an empirical regularity I cannot address here. Gould et al. (2004) and Lagerloef (2005) explicitly model heterogeneity in male skills.

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

[17] Caldwell and Caldwell (1987) discuss the religious belief system and its effect on fertility.

[18] 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.

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. In addition, fathers pay 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 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. f_t^i/n_t^i children per wife) will pay a total cost of $\epsilon(f_t^i/n_t^i)^2 n_t^i = \epsilon(f_t^{i^2}/n_t^i)$. For a man, the cost per child 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]

$$\max \ln (c^y) + \beta \ln (c^o) + \gamma \ln (f^y + f^o)$$

$$\text{subject to } c^y + s^y + pn^y + \epsilon\frac{(f^y)^2}{n^y} \leq w,$$

$$c^o + s^o + pn^o + \epsilon\frac{(f^o)^2}{n^o} \leq (1 + r - \delta)s^y + pd^y,$$

$$a\left(\frac{f^y + f^o}{2} - d^y - d^o\right) \leq (1 + r - \delta)s^o + pd^o,$$

$$d^y \leq \frac{f^y}{2}, \quad d^o \leq \frac{f^o}{2}, \quad c^y,\ c^o,\ d^y,\ d^o,\ f^y,\ f^o,\ n^y,\ n^o \geq 0. \quad (1)$$

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

[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.

[21] The corresponding production function is $f = \sqrt{ng/\epsilon}$, 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 percent from one (World Bank 2003).

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

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. When the bride-price is negative, s^o can be interpreted as a "trust fund" a man sets up to ensure that 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 nonnegativity constraints apply. Note that there are no restrictions on s^y and s^o; that is, there are no borrowing constraints.

Women.—Women have the same utility function and the same endowments as men but make fewer choices. A woman's reproductive rights are sold by her father, and she obeys her husband's fertility decisions. She incurs a cost $\epsilon\bar{f}^2$ to bear $\bar{f}$ children. If she does not have a husband, she cannot bear children.[24] Note that in a polygynous marriage, the number 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 $\bar{f} = f^i/n^i$, where $i = y, o$ is the age of her husband. With her fertility $\bar{f}$ taken as exogenous, a woman solves[25]

$$\max_{c_f^y, c_f^o, s_f} \ln(c_f^y) + \beta \ln(c_f^o) + \gamma \ln(\bar{f})$$

$$\text{subject to } c_f^y + s_f + \epsilon\bar{f}^2 \leq w,$$

$$c_f^o \leq (1 + r - \delta)s_f. \tag{2}$$

Then, a woman's optimal saving decision is

$$s_f = \frac{\beta(w - \epsilon\bar{f}^2)}{1 + \beta}. \tag{3}$$

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).

[24] In this case, a woman would be willing to pay for marriage. However, I assume that marriages can be arranged only by fathers. Hence, no marriage prices are included in the woman's problem.

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

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 shall analyze balanced growth paths of this economy, that is, equilibria in which population and output grow at a constant rate and per capita variables are constant. Let $\eta = M_{t+1}/M_t$ denote the population growth factor. Then the law of motion can be written as

$$\eta^2 = \tfrac{1}{2}(\eta f^y + f^o). \tag{4}$$

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/borrow when young and old, whereas women save only when young. Hence, $K_{t+1} = (s^y + s_f)M_t + s^o M_{t-1}$. On a balanced growth path, the capital-output ratio stays constant. Dividing by Y_t, we can write the capital-output ratio as

$$\frac{K}{Y} = \frac{1}{A}\left[\frac{s_f + s^y + (s^o/\eta)}{2\eta}\right]^{1-\alpha}. \tag{5}$$

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

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

where output per worker is equal to $Y/L = A^{1/(1-\alpha)}(K/Y)^{\alpha/(1-\alpha)}$. Faster-growing populations have lower output per capita, ceteris paribus.

Definition of equilibrium.—I focus on balanced growth path equilibria. Aggregate variables will be growing on such a balanced growth path as a result of endogenous population growth, whereas 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

$$d^y \eta + d^o = n^y \eta^2 + n^o \eta. \tag{6}$$

DEFINITION 1. A balanced growth path (BGP) for the economy in which polygyny is allowed is an allocation that includes consumption (c^y, c^o, c^y, c_f^o), savings (s^y, s^o, s_f), numbers 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 K/Y such that

a. given prices, $(c^y, c^o, s^y, s^o, n, f, d)$ solves the man's problem (1);
b. given prices and $\bar{f}$, (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;
c. population dynamics evolves according to (4);
d. K/Y is given by (5);
e. the market for brides clears (6);
f. profit maximization holds: $w = (1-\alpha)A^{1/(1-\alpha)}(K/Y)^{\alpha/(1-\alpha)}$ and $r = \alpha/(K/Y)$.

The BGP for the economy in which polygyny is banned is defined in the same way, with the only modification that the man's problem has the additional constraint $n^y + n^o \leq 1$.

IV. 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.[26] Analytical results can be derived for the sign of the bride-price, 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 shall present numerical results in Section V.[27] Before turning to the general equilibrium analysis, I shall first briefly discuss the optimal timing of marriage and procreation, given prices.

[26] The proof of the existence of equilibrium is omitted since there are no nonconvexities or discontinuities that could make existence a problem. However, even if an equilibrium exists, there is no guarantee that a BGP equilibrium exists. Indeed for some parameter values, no nontrivial (i.e., $K > 0$) BGP exists.

[27] The equation determining the equilibrium bride-price under monogamy is a highly nonlinear function, whereas under polygyny, equilibrium fertility is the solution of a polynomial equation of degree four.

A. Optimal Timing of Marriage and Childbirth

Women are fecund during only one period, which implies that for a man the marriage and procreation ages must be equal. Further, I have assumed that men are indifferent about the timing of births from a utility perspective. However, the effective costs of marriage and procreation are affected by their timing. For a man it is optimal to marry and have children whenever it is cheapest in discounted terms. If marriage and children are a net cost and the interest rate is positive, then obviously it is better to postpone these costs. However, marriage may be a net revenue (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 bride-price 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[28]

$$c^y + \frac{c^o}{1-\delta+r} \leq w + n^y\left\{\frac{p[f^y/(2n^y)]}{1-\delta+r} - p - \epsilon\left(\frac{f^y}{n^y}\right)^2\right\} + \frac{n^o}{1+r-\delta}\left\{\frac{p[f^o/(2n^o)]}{1-\delta+r} - p - \epsilon\left(\frac{f^o}{n^o}\right)^2\right\}. \qquad (7)$$

From the budget constraint it is obvious that a man would never choose to marry during both periods in his life. From equation (7) it is also clear that, as long as the net interest rate is positive, it is optimal to marry early ($n^y > 0$, $n^o = 0$) if

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

whereas a negative term is consistent only with late marriage as the optimal choice.

B. Polygyny

Using the analysis of the preceding subsection, I can now discuss the characteristics of the polygynous BGP.

PROPOSITION 1. If polygyny is allowed, then any BGP has the following characteristics:

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

1. The bride-price is strictly positive: $p > 0$.
2. All daughters marry: $d^y = f^y/2$ and $d^o = f^o/2$.
3. If there is a BGP with $r > \delta$, then men marry and have children when old: $n^y = 0$, $n^o > 0$, $f^y = 0$, and $f^o > 0$.
4. If there is a BGP with $r < \delta$, then monogamy arises in equilibrium: $n^y = 1$ and $n^o = 0$.

Proof. Part 1 is very intuitive. Suppose $p \leq 0$. Then a man would buy an infinite number of wives because this would strictly decrease child-rearing costs, that is, provide the same utility at a lower cost. This cannot be an equilibrium. Part 2 follows immediately from part 1: given a positive bride-price, it is optimal for a man to sell all his daughters. Part 3 follows from the budget constraint (7) as follows. First note that neither of the terms in brackets can be strictly positive in equilibrium because if either of them were, a man would demand an infinite number of wives, which cannot be an equilibrium. If $r > \delta$, then it is cheaper to have children in the second period. Since f^y and f^o enter symmetrically into the utility function, men would always choose $f^o > 0$, $n^o > 0$, and $f^y = n^y = 0$ in this case, which proves part 3. If, on the other hand, $r < \delta$, then $n^y > 0$ and $n^o = 0$ is optimal. From the market-clearing condition (6) together with part 2 of this proposition, it follows that $n^y = f^y/(2\eta)$. But from equation (4) we know that $\eta = f^y/2$ and hence $n^y = 1$, which proves part 4. QED

Proposition 1 establishes that polygyny can occur only as long as the net interest rate is positive. As discussed in Section II, a high fraction of men in sub-Saharan Africa have multiple wives; hence, part 4 describes a BGP that is not relevant for this region. In the remainder of the paper I shall therefore focus on BGPs as characterized in part 3.

With 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 (4) gives the population growth factor: $\eta = \sqrt{f/2}$. Market clearing for brides (6) together with the population growth factor gives the number of wives: $n^o = \sqrt{f/2}$. Therefore, as long as women have at least two children, polygyny happens in equilibrium despite a balanced sex ratio and a homogeneous population.[29] Polygyny is feasible because of a growing population and spousal age gaps. Finally, the total fertility rate is $f/n^o = \sqrt{2f}$. With these results, the man's problem sim-

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

plifies to

$$\max_{c,f,n,s} \ln (c^y) + \beta \ln (c^o) + \gamma \ln (f)$$

$$\text{subject to } c^y + s \leq w,$$

$$c^o + \epsilon \frac{f^2}{n} + pn \leq (1 + r - \delta)s + \frac{p(f/2)}{1 + r - \delta}. \tag{8}$$

The first-order conditions of this problem are[30]

$$\frac{\beta}{c^o} 2\epsilon \frac{f}{n} = \frac{\gamma}{f} + \frac{p\beta}{2c^o(1 + r - \delta)}, \tag{9}$$

$$p = \epsilon \left(\frac{f}{n}\right)^2, \tag{10}$$

and

$$\frac{1}{c^y} = \frac{\beta}{c^o}(1 + r - \delta). \tag{11}$$

Equation (9) equates the marginal costs and benefits of having children. Note that the marginal benefit 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 bride-price, and the benefit is the change in the cost of child rearing. Equation (11) compares the marginal utility from consumption when young to the discounted marginal utility from consumption when old.

This discussion, together with definition 1 and proposition 1, gives a system of equations that can be used to construct the polygynous BGP equilibrium.

Proposition 2. A polygynous BGP for this economy can be constructed by solving the following system of 13 unknowns (c^y, c^o, s, f, n, c_f^y, c_f^o, s_f, w, r, K/Y, η, and p) and 13 equations: two binding budget constraints from problem (8); two factor price conditions from definition 1; three first-order conditions, (9), (10), and (11); two binding budget constraints from problem (2); $s_f = \beta[w - \epsilon(f/n)^2]/(1 + \beta)$ from equation (3); the bride market-clearing condition, $n = \sqrt{f/2}$; the law of motion for population dynamics, $\eta = \sqrt{f/2}$; and capital market clearing, $K/Y = (1/A)[(s_f + s)/(2\eta)]^{1-\alpha}$.

[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).

C. *Monogamy*

The predictions for monogamy are more varied. For example, if the parameters in the polygynous model are such that population growth is exactly zero, 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 case is not a very interesting one, since population growth is positive in almost all developing countries. To exclude this 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 two.[31]

With positive population growth, there are two distinct possible outcomes. Note that universal monogamous marriage for women is possible in equilibrium only if there is no age gap. For this to be an equilibrium, the bride-price has to adjust such that men (weakly) prefer to marry when young. Depending on parameters, the bride-price that assures this indifference is negative and so large in absolute value that men prefer not to marry off their daughters and instead pay the cost a. If this is the case, then there is no BGP equilibrium in which all women marry. Instead, there is an age gap and a fraction of daughters remain unmarried. The number of daughters that marry is then equal to the population growth rate (this follows from [6]), whereas the total number of daughters is $f^o/2 = \eta^2$ from (4). Together these equations yield that only a fraction $1/\eta$ of daughters marry. Thus $(\eta - 1)/\eta$ percent of all women never marry. For this to be an equilibrium, fathers need to be indifferent regarding their daughters' marital prospects; hence $p = -a$. Proposition 3 summarizes this discussion.

Proposition 3. (1) If there is a BGP with positive population growth in which all women marry, then there is no spousal age gap ($f^y > 0$, $n^y = 1$, and $f^o = n^o = 0$) and $p \geq -a$. (2) If there is a BGP with positive population growth in which some women remain unmarried, then there is a spousal age gap ($f^o > 0$, $n^o = 1$, and $f^y = n^y = 0$), the fraction of unmarried women is $(\eta - 1)/\eta$, and $p = -a$.

Large numbers of single women are not observed historically. Hence, in the following I focus on BGPs in which all women marry and men sell all their daughters (case 1). Conditional on marrying young, the

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

man's problem can be written as

$$V^y(p) = \max \ln (c^y) + \beta \ln (c^o) + \gamma \ln (f)$$
$$\text{subject to } c^y + s + p + \epsilon f^2 \leq w,$$
$$c^o \leq (1 + r - \delta)s + p\frac{f}{2}. \qquad (12)$$

The first-order conditions are

$$\frac{\gamma}{f} = \frac{2\epsilon f}{c^y} - \frac{p\beta}{2c^o} \qquad (13)$$

and

$$\frac{1}{c^y} = \frac{\beta}{c^o}(1 - \delta + r). \qquad (14)$$

In equilibrium, the bride-price adjusts to assure that marrying young is (weakly) better than marrying when old:

$$V^y(p) \geq V^o(p), \qquad (15)$$

where

$$V^o(p) = \max \ln (c^y) + \beta \ln (c^o) + \gamma \ln (f)$$
$$\text{subject to } c^y + \frac{c^o + p + \epsilon f^2}{1 + r - \delta} \leq w + \frac{p(f/2)}{(1 + r - \delta)^2}.$$

Proposition 4 summarizes this discussion by giving a system of equations that can be used to construct a monogamous BGP equilibrium.

Proposition 4. A monogamous BGP with positive population growth in which all women marry can be constructed by solving the following system of 12 unknowns (c^y, c^o, s, f, c_f^y, c_f^o, s_f, w, r, K/Y, η, and p) and 12 equations: two binding budget constraints from problem (12); two factor price conditions from definition 1; two first-order conditions, (13) and (14); two binding budget constraints from problem (2); $s_f = \beta(w - \epsilon f^2)/(1 + \beta)$ from equation (3); capital market clearing, $K/Y = (1/A)[(s_f + s)/(2\eta)]^{1-\alpha}$; the population law of motion, $\eta = f/2$; and equation (15).

A main channel emphasized in this paper is the endogenous bride-price. One would thus like to know the model's prediction for the sign of the bride-price. First note from proposition 3 that any BGP with positive population growth and some unmarried women has a strictly negative bride-price. However, as argued before, the case of universal marriage for women seems the more relevant one. One cannot solve for the bride-price explicitly in this case, which makes general statements difficult. However, numerical examples with a negative equilibrium bride-price are abundant, which is in sharp contrast to the polygynous economy, where the bride-price is *always* strictly positive.

In the end, the sign of the bride-price is a quantitative question, and for the calibrated model discussed in the next section, it turns out to be strictly negative. In fact, I have not been able to construct a single numerical example with a positive equilibrium bride-price in a monogamous economy with positive net interest rates and positive population growth. I conjecture that this result is quite general. The intuition is as follows. At given prices, r and w, it is indeed possible that $V^y(p) = V^o(p)$ for some $p > 0$. However, this equality seems to imply that having children is very profitable, which means that men want to have them early and want to borrow against future revenues from the sale of daughters to finance the current expenditures on child rearing. Generally, these forces seem to generate a negative aggregate savings rate, which cannot be an equilibrium. To prove this conjecture, one would like to derive an expression for the aggregate capital stock as a function of the bride-price only. However, this is not possible because of the lack of closed-form solutions.

V. 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 were introduced. To do this experiment, I calibrate the polygynous BGP to the "average polygynous country" as described in Section II.*A*. 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. I consider this case to be the relevant one for the quantitative exercise, since marriage rates are close to 100 percent in all developing countries and almost always higher for women than for men (see U.N. Population Division 2000).[32]

Finally, there is a multiplicity in the equilibrium dowry. For the numerical results, I assume that the dowry is such that it makes men exactly

[32] Moreover, the BGP of case 2 in proposition 3 is arguably not very stable since single women would have a strong desire to pay for their own marriages, which is ruled out by the assumption of complete paternal control.

TABLE 2
Calibration

Parameter	Value	Matched to Fit
γ	.58	Surviving number of children = 5.01
β	.46	Annual discount factor = .95
ϵ	44	S/Y = 13%
A	433	GDP per capita normalized to $975
α	.4	Income share of capital = 40%
δ	.66	7% annual depreciation

indifferent between n^y and n^o. That is, I assume that (15) holds with equality. Other monogamous equilibria involve higher dowries, which makes children even more costly and hence decreases further the incentives to have children. 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.

A. *Calibrating the Polygynous Economy*

To determine the appropriate values for the parameters, some assumptions linking the model to observable data need to be made. A model period is chosen to be 15 years because that is roughly the age at which 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. Since this model abstracts from mortality, I define fertility in the model as the number of children who survive until at least age 5.

The model has six 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. These parameters are chosen to match data for the average polygynous country from Section II.*A*.

The TFP parameter A is a pure scale parameter used to normalize per capita output to the level in the data, $975. The annual discount factor is set equal to 0.95 in line with the macro literature. Annual depreciation of 7 percent 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 two parameters, γ and ϵ, are calibrated to match the surviving number of children and saving rates from table 1. Table 2 summarizes the calibration.

TABLE 3
NUMERICAL RESULTS

	POLYGYNY: Model and Data	MONOGAMY	
		Model	Data
Surviving fertility	5.01	2.91	3.57
Savings rate	.13	.22	.19
GDP per capita	$975	$2,648	$2,798

B. *Results*

Table 3 summarizes the main results. It shows that allowing for polygyny induces men to marry several wives, to have many children, and to save little.

When polygyny is banned, fertility falls and savings rise, which compares well to the data.[33] The monogamous BGP has a fertility rate that is 42 percent lower than the polygynous one, compared to a 29 percent lower fertility rate in the data. The model also predicts that savings are much higher under monogamy, which is also seen in the data. Output per capita is 2.7 times the output in the polygynous economy, whereas in the data it is 2.6 times as high. I show in Appendix B that these results are fairly robust.

Contrary to standard models, small differences in savings rates lead to relatively large differences in GDP per capita in this model. This amplification is due to the difference in population growth rates that affect GDP per capita through two additional channels. First, a higher population growth rate dilutes the capital stock more; that is, it leads to a lower capital-output ratio for a given savings rate. Second, since only young adults supply labor, a higher population growth rate leads to a higher dependency ratio, which means that output *per capita* is lower for a given level of output *per worker*. The ratio of output per capita in the monogamous (m) versus polygynous (p) society is related to the ratio of investment rates as follows:

$$\frac{Y^m_{pc}}{Y^p_{pc}} = \frac{1+\eta^p+(1/\eta^p)}{1+\eta^m+(1/\eta^m)}\left[\frac{(\eta^p-1+\delta)(I^m/Y^m)}{(\eta^m-1+\delta)(I^p/Y^p)}\right]^{\alpha/(1-\alpha)}. \tag{16}$$

As noted in Section I, countries obviously differ by more than marriage law. It is also well established that TFP differences matter. Hence, the fact that this model can explain all the GDP differences through

[33] As stressed in Sec. I, I focus on differences in marriage law and abstract from all other differences across countries. I therefore prefer to interpret my results as indicating what would happen in sub-Saharan Africa if monogamy were enforced rather than as an explanation for cross-country differences.

TABLE 4
Further Implications of the Model

	Polygyny		Monogamy	
	Model	Data	Model	Data
Wives per man	2.5	1.34	1	1
Age gap	15	6.4	0	2.8
Annual population growth	6.3%	2.7%	2.5%	2.2%
Bride-price	\$158		−\$2,412	
Total marriage payments/GDP	5.2%		14.6%	
Total child-rearing costs/GDP	29.0%		4.5%	
Male utility	12.28		12.73	
Female utility	11.27		12.46	

observable factors is not necessarily a success. Note, however, that the results above imply too large differences in the population growth rate relative to the data (see table 4), which makes the amplification in (16) too large. This happens because the analysis ignores mortality differences beyond age 5. In Appendix B, I calibrate the model to a lower fertility rate, which lowers the population growth rate and thereby shrinks the GDP per capita differences to a factor of two.[34]

Table 4 summarizes further implications of the model. The first three rows compare the model's implied average number of wives, population growth rates, and age gaps to the data. The model does less well in replicating these demographic features quantitatively. This weakness is due partly to the limited number of periods and partly to abstracting from mortality, as argued above. However, the model is able to replicate the demographic differences qualitatively.

Owing to the limited number of periods in the model, the age gap can be only either zero or 15. The model therefore predicts an age gap of 15 years for the polygynous economy, compared to zero years for the monogamous economy. In the data, the age gaps are 6.4 and 2.8 years, respectively.

Table 4 also reports the size of marriage payments relative to GDP in the model. Total marriage payments are higher under monogamy. The equilibrium bride-price in the monogamous economy is −\$2,421, which means that a man at marriage receives a payment amounting to about 50 percent of his wage. The equilibrium bride-price under polygyny is only \$158. This means that an old man who marries the equilibrium number of wives has to pay a total of \$395, or 17 percent of the wage of a young man, to pay for his brides.

The table also shows that total expenditures on children are much higher under polygyny than under monogamy. In fact, 29 percent of

[34] Note that to match both fertility and population growth rates from the data, one would need to introduce mortality explicitly into the model.

GDP is spent on producing children in the polygynous economy, whereas only 4.5 percent of resources are devoted to child production in the monogamous economy. This large difference is due partly to higher fertility in the polygynous economy and partly to a higher average child cost. These additional predictions could be used to further assess the model. Since data on these magnitudes are not easily available, this task is left for future work.

Finally, table 4 shows that steady-state utility for both men and women is higher under monogamy than under polygyny. However, this result does not necessarily imply that 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.[35]

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 the form of bride-prices as social security transfers. Of course the analogy is not perfect since the amount of the transfers is endogenous here, whereas it would be exogenous in a model with social security.

VI. 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 bride is strictly positive, whereas 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 bride-price 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 percent, increases savings by 70 percent, and raises output per person by 170 percent. These figures suggest that, although the practice of polygyny is certainly not the sole cause of poverty, it might be an

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

important contributing factor to 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 actual marriage behavior. An alternative policy often proposed by development institutions such as 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 60 percent; the effects on fertility and the number of wives are small, which 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.

Appendix A

Data

A. Data for Polygynous Countries

Table A1 includes all countries in which more than 10 percent of married men have multiple wives (see also n. 6).[36]

TABLE A1
POLYGYNOUS COUNTRIES

Country	Sexrat	Pol1	Pol2	Pol3	Price	TFR	CMR	Gap	Marr1	Marr2
Bangladesh	49.6	11.3	6.3	. . .	BD	6.12	211	6.8	51.3	99.3
Benin	50.7	31	45.4	1.4	B	7	214	. . .	29.1	. . .
Burkina Faso	50.5	40.2	53.7	1.7	B	7.5	. . .	8.6	34.6	97.2
Cameroon	50	55.6	57.7	1.4	B	6.42	173	6.5	35.8	99.2
Central African Republic	51.2	13.3	28.5	1.3	B	5.77	. . .	5	42.3	99
Chad	50.5	22	39.1	. . .	B	6.86	235	6.1	48.6	100
Comoros	. . .	. . .	25	. . .	B	7.2	165	4.9	11.5	98.1
Congo, Democratic Republic	50.5	19.5	32.1	1.3	B	6.62	210	8.3	74.2	95.4
Congo, Republic	51	31.9	38.1	1.6	B	6.29	125	8.6	55.5	92.9
Cote d'Ivoire	49.2	20.2	34.8	1.3	B	7.41	170	7.2	27.7	98.4
Gabon	50.5	27.3	21.1	1.4	B	4.46	. . .	3.9	15.9	87.2
Gambia	50.5	35.1	20	. . .	B	6.5	216	9.2	43.6	100
Ghana	50.2	16.3	22.5	1.2	B	6.5	157	5.7	22.4	98.9
Guinea	49.7	37.1	53.3	1.6	B	6.08	. . .	7.3	49	99.7
Kenya	49.9	12.5	16	1.2	B	7.82	115	4.6	16.7	98.8
Kuwait	46.8	11.7	. . .	. . .	B	5.3	35	3.3	13.2	96.3
Liberia	49.7	. . .	38	1.3	B	6.8	235	6.5	35.7	93.4
Malawi	50.8	10.2	20.4	. . .	B	7.6	265	4.9	43.6	98.2
Mali	51	29.3	42.4	1.3	B	7.1	. . .	7.4	49.7	99.6
Mauritania	50.4	. . .	11.2	1.1	B	6.38	188	7.6	36	95.7
Mozambique	51.4	11	27.3	1.2	B	6.5	. . .	4.6	47.1	99.3
Niger	50.6	15.2	37.6	1.3	B	8	317	6.3	61.9	99.6
Nigeria	50.6	. . .	35	. . .	B	6.9	196	6.9	36.1	95.9
Rwanda	50.5	. . .	12.1	1.2	B	8.26	. . .	. . .	9.8	. . .
Senegal	50.2	40.7	46	1.5	B	6.82	. . .	8.1	43.8	95.4
Sudan	49.7	15.9	20.1	1.2	B	6.12	145	6.3	21.3	96.3
Tanzania	50.4	15.9	28	1.2	B	6.74	176	4.5	. . .	97.1
Togo	50.3	31.9	42.8	1.5	B	6.78	188	5.7	19.9	98.9
Uganda	50	15.8	32.2	. . .	B	7.22	180	4.3	49.8	96.9
Average*	50.36	24.31	31.67	1.34	. . .	6.78	194.05	6.38	37.51	97.32

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

The data definitions are as follows.

Sexrat: Sex ratio: percentage of the population that is female.

Pol1: Percentage of married men in a polygynous union (both legal marriages and cohabiting unions).

Pol2: Percentage of married women in a polygynous union (both legal marriages and cohabiting unions).

Pol3: Average number of wives per married man.

Price: B = brideprice, D = dowry.

[36] Polygynous countries in which less than 10 percent of all marriages are polygynous are Iran, Algeria, Syrian Arab Republic, Egypt, Ethiopia, Pakistan, Morocco, Libya, Lebanon, Jordan, Tunisia, Yemen, India, Bahrain, Iraq, United Arab Emirates, Oman, and many sub-Saharan African countries.

TFR: Total fertility rate: estimated number of children per woman over her life cycle using current age-specific live birth rates, 1980.

IMR: Infant mortality rate: number of live births per 1,000 that die before the first birthday, 1980.

CMR: Child mortality rate: number of live births per 1,000 that die before age 5, 1980.

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

Marr1: Proportion of ever-married women aged 15–19.

Marr2: Proportion of ever-married men aged 45–49 (Marr1 and Marr2 include consensual unions in some countries; see U.N. Population Division [2000] for a detailed description).

B. Data Sources

Data on polygyny are taken from the United Nations (1990), Bankole and Singh (1998), the World Bank (2004), and the 2005 Demographic and Health Surveys (http://www.measuredhs.com/statcompiler); for each country I use the latest year of data available. Fertility and mortality rates are taken from the World Bank (2002). The U.N. Population Division (2000) provides data on the fractions of men and women who are married, as well as data on average ages at first marriage and the age gap between husbands and wives. Population growth rates and life expectancy are taken 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 taken from the Penn World Table, version 5.6a (see Summers and Heston 1991).

Appendix B

Robustness

To see how sensitive the results are to changes in the parameters, I shall report two alternative calibrations here. As was discussed in the 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 panel A of table B1. 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 percent is too high because of incorrect measurement of self-employment and that the true output share of capital is lower. Panel B of table B1 therefore reports the results for a calibration to $\alpha = 0.35$. The results show that this capital share 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 on request.

TABLE B1
NUMERICAL RESULTS (Robustness)

	Polygyny: Model and Data	Monogamy	
		Model	Data
	A. Lowering Fertility		
Surviving fertility	4.00	2.45	3.57
Investment rate	.13	.18	.19
GDP per capita	$975	$2,107	$2,798
	B. $\alpha = .35$		
Surviving fertility	5.01	2.28	3.57
Investment rate	.13	.28	.19
GDP per capita	$975	$3,258	$2,798

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