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The Mystery of Monogamy

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Abstract

This paper examines why developed countries are monogamous while rich men throughout history have tended to practice polygyny (multiple wives). Wealth inequality naturally produces multiple wives for rich men in a standard model of the marriage market. This paper argues that the sources of inequality, not just the level of inequality, determine the equilibrium degree of monogamy or polygyny. In particular, when inequality is determined more by disparities in human capital versus non-labor income (such as land, capital, corruption), the outcome is more monogamous. This explains why developed countries, where human capital is the main source of income and inequality, are monogamous while less-developed economies tend to be polygynous. The results are driven by the larger inequality in the value of women in the marriage market in modern economies. When the value of human capital increases, rich men increasingly value quality women who can help them raise quality children more efficiently. As a result, high quality women are valued much more than low quality women, which makes polygyny less affordable for rich men. In this manner, we show that male inequality generates polygyny, but female inequality reduces it. Using data from Cote d'Ivoire, we provide evidence for all the main implications of the model. In particular, we control for a man's total income and show that polygyny increases with non-labor income but decreases with labor income and education. These patterns are strong even within social groups where norms regarding polygyny are likely to be constant.

Keywords: Marriage, Monogamy, Polygyny, Human Capital, Inequality.

JEL Classification Numbers: J12, J24, O10, O40.

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1 Introduction

Throughout history, wealthy men have tended to mate with multiple wives. This practice, known as polygyny, exists in 850 of the 1170 societies recorded in Murdock's Ethnographic Atlas (Hartung (1982)). Polygyny is still prevalent in much of Africa where the percent of women living in polygynous households ranges from 25% to 55% in the Western, Central, and Eastern parts (Lesthaege (1986)). Moreover, polygyny is very easy to explain theoretically – male inequality in wealth tends to generate inequality in the number of their wives (Becker (1991)). If all men were equal, there would be no reason for a woman to become the second wife of a man when she can just as easily be the only wife of someone just as good. However, it is not well understood why polygyny is virtually non-existent in modern industrialized societies, or in other words, why polygyny is so strongly associated with primitive economies both today and throughout history. Given the large and often staggering disparities in wealth in many highly developed countries, it is somewhat of a mystery that monogamy has emerged almost universally in the marriage market of advanced economies.

Therefore, the primary goal of this paper is to offer an explanation for the emergence of monogamy as an equilibrium outcome even in the presence of persistently high levels of income inequality. Our model demonstrates that a key factor explaining the practice of monogamy versus polygyny is not just the level of inequality, but also the composition of inequality. In particular, income is derived from labor income, which is a function of human capital, and non-labor income such as land, physical capital, corruption, etc. The model shows that the marriage market equilibrium becomes more monogamous as the level of inequality is determined more by disparities in human capital versus disparities in non-labor income. This result is consistent with the idea that inequality in advanced economies is determined more by differences in human capital, while inequality in less-developed societies is primarily due to a skewed distribution of non-labor income.[1]

A key assumption of the model is that high quality men and women are more efficient in producing higher quality children, which generates a comparative advantage for high quality parents in raising higher quality children. Therefore, the rich men in less-developed

[1]For example, labor income explains 72% of the variation in total income for male heads of households in the United States 1990 Census versus only 54% in Cote d'Ivoire in 1986 (see the empirical section for a description of the Cote d'Ivoire data). Using log income and log wages, these numbers are 18% for the US and 6% for Cote d'Ivoire. Also, this notion is consistent with the empirical growth literature which shows that the negative effect of land inequality on growth is usually found to be stronger than income inequality. See Alesina and Rodrik (1994) and Deininger and Squire (1998).

economies, who typically have high non-labor income and low human capital, do not produce quality children efficiently. As a result, rich men in less-developed economies have a low demand for quality children, which translates into a low demand for quality in women, since quality in women is valued only for its advantage in producing quality children. Hence, the value of women in the marriage market is determined by the quantity, rather than the quality of children that women can produce. Assuming that all women produce a similar expected number of children, all women are close substitutes for each other in the marriage market in primitive economies, which keeps the price low enough so that rich men can afford more than one wife. Consequently, rich men in primitive economies marry multiple wives and have many children with low levels of human capital.

In more advanced economies, human capital plays a larger role in determining the level of income and inequality. Therefore, the wealthy men are typically men of higher quality, not just those with more non-labor income. As a result, wealthy men have a higher demand for child quality versus quantity because their cost of producing child quality is low relative to the return. The increased demand for quality children increases the demand for quality in women in the marriage market, since high quality men and women are complements in the production of quality children. Thus, women are valued according to both the quality and quantity of children they can produce, and therefore, high quality women are a scarce resource in the marriage market in advanced economies. As a result, women of different quality levels are not highly substitutable for each other, and the high value of quality women increases their price in the marriage market and makes polygyny less affordable for rich men who want high quality wives. Monogamy emerges in advance economies because of the increasing value of high quality women in the marriage market, which stems from the increasing value of their input in the production of child quality.[2]

In other words, male inequality generates polygyny, but female inequality reduces it. The model shows that inequality in the value of women is necessary to reduce the degree of polygynous mating – there needs to be a reason why rich men are willing to pay more for less quantity. The model also shows how female inequality is generated. The value of women in the marriage market is shown to be directly linked to the importance of her children's human capital. Therefore, when human capital is a bigger factor in determining

[2] Theoretically, the switch towards quality versus quantity in advanced economies, as in Becker, Murphy and Tamura (1990), could increase the demand for polygyny if a rich man tries to increase quality by decreasing the number of children per wife, and therefore, may lead to an offsetting increase in the number of wives. This equilibrium does not occur in our model since the comparative advantage of quality women in producing quality children drives up the price of quality women to the point of making polygyny less affordable.

her child's future income, women who can create high quality children more efficiently are increasingly valued in comparison to low quality women. This inequality within women directly influences the degree of polygynous matching in equilibrium. As a result, male inequality in less-developed societies translates into inequality in the number of wives per man, while inequality in developed countries generates inequality in the quality of wives. Becker (1991) calls inequality in the quality of wives "implicit polygyny," which our model shows is the equilibrium outcome when the source of inequality stems mainly from human capital because of the inequality in the value of women in the marriage market.

The model also offers an explanation of why and how the "power of women" is higher in advanced societies. The increasing "power of women" derives from the increasing value of their ability to produce quality children, and therefore, the model is consistent with the roughly equal division of household resources within modern, monogamous marriages. In addition, our analysis using data from Cote d'Ivoire confirms all the main implications of the model. In particular, we control for a man's total income and show that polygyny increases with non-labor income but decreases with labor income and education. This result is consistent with the main prediction of our model: the sources of income, in addition to the level of income, strongly determine the degree of polygynous behavior in the marriage market.

It may be tempting to argue that the mystery of monogamy is easily explained by bans on polygynous behavior in modern societies, or social norms in favor of monogamy. We do not dismiss these factors as inconsequential, however, they are unlikely to be the entire explanation for several reasons. First of all, bans on polygyny may seem to be effective in Western countries, but polygyny is also banned in many less-developed countries with persistently high rates of polygynous mating (Western Africa, Thailand, Egypt, etc.). Clearly, bans on polygyny do not guarantee monogamy, precisely because of the difficulty of enforcement – it is very hard to stop consenting adults from living together and having children. Secondly, if there are effective laws or norms against polygyny, how did they arise? If their existence is independent from economic considerations, then norms against polygyny should not be so strongly correlated with economic development, investments in child quality, assortative mating between high quality husbands and wives, and the increasing power of women within the household and in society. Furthermore, our analysis on Cote d'Ivoire shows that the different sources of income explain variation in the polygynous behavior of individuals within religion and area of residence, where social norms about polygyny are likely to be constant.

Therefore, it seems more likely that norms and economic motives work together and reinforce each other. This line of reasoning follows Becker (1991) and Elster (1989), who argue that although laws and norms may affect behavior, they rarely evolve and are maintained if personal incentives are very weak to uphold them. Our model should be considered an attempt to explain how personal incentives align themselves with norms at various stages of development. In particular, our model shows how the demand for polygyny declines naturally in advanced countries, so that social norms can evolve and reinforce a monogamous outcome. As a result, our model can help explain why norms in favor of monogamy are strongly correlated with so many economic patterns listed above.

In addition, our model can be used to show within a simple political economy context why monogamous norms and laws emerge in the first place. Becker (1991) points out that, in contrast to conventional wisdom, women are not the ones primarily harmed by polygyny, since polygyny offers additional options for women. The real victims of polygyny are poor men, who may face very dim marriage prospects if they have to compete with rich men in a polygynous market. Given that rich men usually exercise more political and social power than poor men, rich men will only create laws or norms allowing for polygyny when their benefit from polygyny is high relative to the potential costs of social unrest stemming from inequality in the marriage market. That is, in advanced countries, the political economy gains for rich men of giving the "benefit" of monogamy to poorer men outweighs the rather small cost of limiting themselves to only one wife, which our model predicts is already the equilibrium tendency. But, in poorer countries where the demand for polygyny by rich men is high according to our model, the cost of limiting themselves to one woman is very high, and therefore, the rich and powerful are likely to keep the privilege of polygyny for themselves and deal with the potential wrath of the lower classes in other ways.

Considering the prevalence of polygyny throughout history and even today in many less-developed economies, there is surprisingly very little written about this issue.[3] Most models about marriage behavior assume monogamous mating. Becker (1991) presents the classic model of the marriage market which does allow for multiple partners, and

[3]It is somewhat debatable whether there is no polygyny in modern societies like the United States. Even if we disregard certain Mormon groups which are explicitly polygynous, many men are "serial monogamists" in the sense of marrying multiple wives in succession. This could be considered a form of polygyny, and points to the overall difficulty in categorizing various societies over time as either polygynous or monogamous. The very definition of marriage is not comparable in all places and over time. For example, concubines in China had certain privileges which were similar to wives, and the concept of marriage in Africa today is not the same as in Western societies. However, despite all this variation, our model seeks to explain the seemingly ubiquitous decline in polygyny in modern societies, using the working definition of a "wife" as someone a man lives with and raises children with.

shows that inequality in men naturally leads to polygyny. Becker's analysis has been extended by Bergstrom (1994a and 1994b), Guner (1999), Lagerlof (2002), and Edlund and Lagerlof (2002). The focus of these papers is to analyze the degree of polygyny within a less-developed economy, and investigate the interaction between the practice of polygyny with a host of other marriage market institutions in agrarian economies such as arranged marriages, dowries, bride prices, support of parents in old age, investments in sons versus daughters, and the division of bequests to children. In contrast, our focus is to explain why polygyny virtually disappears in advanced countries, and not on the interaction of polygyny and the myriad of mostly primitive marriage market customs. The existing models are limited in their ability to explain the downfall of polygyny in advanced countries, since polygyny is very hard to rule out whenever there is inequality in men. Consequently, our model is the first to explain monogamy in the presence of large and persistent inequality within men, and to link monogamous tendencies with the increasing value of women in creating quality children.[4]

Many of the existing models also have predictions which are clearly specific to the setting of an agrarian economy. For example, Becker (1991) predicts that polygyny is positively associated with increasing transfers to the bride ("bride-prices") and with the increasing productivity of women in the output market.[5] Both of these predictions have strong empirical support in agrarian economies such as Africa (see Goode (1963), Grossbard (1976), and Jacoby (1995)). However, these predictions are problematic regarding advanced economies where the productivity of women and the implicit bride price (bargaining power) of women are the highest they have ever been. According to existing models, the high productivity and bargaining power of women should be a sign of higher rates of polygyny, not the virtual extinction of polygyny as we see today. In contrast, our model is consistent with the decline in polygyny accompanied by the increasing bar-

[4]Lagerlof (2002) looks at the interaction of many of the various marriage market customs and practices in a dynamic context, and consequently, does offer an explanation for the decline in polygyny in advanced countries. However, the explanation, while not the focus of the paper, relies on the elimination of inequality to eliminate polygyny. In contrast, our model is the first to explain monogamy when inequality is still prevalent and sizeable.

[5]If female productivity in the market is associated with higher rates of polygyny in less developed economies, it is not clear why the equilibrium prices of wives and outside labor in competitive marriage and labor markets would not adjust to reduce the incidence of polygyny. Therefore, to explain the persistence of polygyny in less-developed economies and the near extinction of polygyny in highly developed economies, we focus on the primary function of a marriage - the production of child quantity and quality. The production of children has no substitute in the outside labor market. Therefore, we focus on the role of polygyny in determining the fundamental choice and trade-off between child quantity and quality that all men and women make in both high and less-developed economies.

gaining power of women in marriages, increasing productivity of women, and persistent income inequality within men. We argue that while polygyny may increase bride prices within agrarian-based societies, the existence of polygyny in general is a sign that wives are inexpensive, or else wealthy men would not be able to afford more than one.

This paper is also related to the recent research concerning marriage patterns, macroeconomic conditions, and inequality (see Kremer (1997), Aiyagari, Greenwood, and Guner (2000), Fernandez and Rogerson (2001); Fernandez, Guner, and Knowles (2001)). This literature mainly focuses on the effect of assortative monogamous mating on the inequality of household income. In contrast, we examine the reverse effect of inequality on assortative mating, and we consider assortative mating in terms of not only the quality of husbands and wives, but also on the quantity of wives (i.e. assortative polygynous mating). However, a main prediction of our model is that there will be higher rates of assortative mating between men and women of higher quality in more advanced countries and in countries where there is a higher skill premium. Fernandez, Guner, and Knowles (2001) provide empirical evidence for these predictions, thus supporting our story behind the decline of polygyny in advanced economies.

Finally, it is worth noting that monogamy is not just a mystery to economists. For example, anthropologist Laura Betzig frequently questions why monogamy is so strongly associated with development.[6] Betzig (1995) writes:

> *That leaves me with my favorite question. When, and why did polygyny and despotism end, and monogamy and democracy begin? Some people have said*

[6]It is beyond the scope of this paper to answer the question of when and where monogamy began. Betzig (1992, 1995) argues that the Greeks, Romans, and Europeans in the Middle Ages exhibited strong polygynous tendencies – with rich men marrying multiple wives, or having children with concubines and mistresses. Betzig (1995) argues that "polygynous mating died, or began its last gasps, after the Middle Ages were over; and the Church probably had little to do with its demise." Her opinion is shared by others. Posner (1992) writes about the widespread practice of concubinage in Greece and Rome. Also, Pierre Grimal (1986) writes that "At no period in Roman history was the presence of a concubine in the house considered discreditable" and that "In the course of time the institution of concubinage became a sort of unofficial marriage." Concerning "polygyny" in the Middle Ages, George Duby (1983) writes that "Illegitimacy was a normal part of the structure of ordinary society – so normal that illegitimate children, especially males, were neither concealed nor rejected." Jack Goody (1983) writes that "In Christian Europe, however, concubinage was 'illegal' and its offspring were illegitimate. Yet despite the constant admonitions against it, the practice flourished among laity and clerics alike." Concerning England in the Middle Ages, Lawrence Stone (1977) writes that "In the early sixteenth century open maintenance of a mistress – usually of lower-class origins – was perfectly compatible with a respected social position and stable marriage . . . up to about 1560 they are often to be found leaving bequests to bastard children in their wills. In practice, if not in theory, the early-sixteenth century nobility was a polygamous society." Hence, it seems that, consistent with our theory, the emergence of monogamy coincides with the increasing importance and spread of human capital in the Industrial Revolution. (see the survey of the evidence in Galor and Moav (2004)).

the Roman Empire was monogamous. This evidence is not persuasive. Others have said monogamy began in the Middle Ages under the Catholic Church. But political, economic, and even reproductive inequality seem to have characterized medieval Europe too. It seems to me that one event changed all that: the switch to an industrial economy in Europe in the past few centuries.

This paper offers an explanation to this question.

2 The Model

In this section, we set up a general equilibrium model of the marriage market which allows for polygynous matching. The goal is to determine which factors push the equilibrium to be more polygynous or more monogamous, and to study under what circumstances monogamy can exist at all. The underlying mechanism is based on the interaction of polygynous mating with the trade-off between child quantity and child quality.

The model consists of a marriage market organized by contracts that specify the allocation of resources within the household and investments in child quality. A key assumption of the model is that skilled men and women have a comparative advantage in raising quality children. Throughout the analysis, the term "skill" will refer to the level of human capital and will be used interchangeably with the term "quality." In this sense, human capital should be thought of as both formal and informal schooling and training both inside and outside the home.

The marriage market consists of two types of men and women - high and low quality. The proportion of men and women with high human capital is denoted by θ. Men are allowed to offer women of either type a marriage contract, and if she accepts, they get married and have two children, a boy and a girl.[7] A marriage contract consists of three components: (1) a "price" which specifies an income transfer from the husband to the wife for her personal consumption, (2) a human capital level for their offspring which requires a certain investment by the household, and (3) a "bequest" to the wife's children for their consumption. Thus, the contract specifies the division of household resources between the man, his wife or wives, and each child. Moreover, the contract specifies whether resources

[7]Since the goal of this paper is to study the distribution of the number of wives across men, we normalize the number of children each woman bears to two - a boy and a girl. Thus, we will not try to explain polygyny with an imbalanced sex-ratio, which could also result from younger women marrying older men in a growing population. It would be trivial to develop a model with men marrying multiple women if there are a lot more women than men. We believe that sex-ratios may be an important factor, but they cannot explain the broad correlation between development and monogamy.

are transferred to the children in the form of investments in their human capital and/or bequests in the form of income. Men are allowed to marry as many wives as they wish subject to their budget constraint. Furthermore, we assume that men earn income in the labor market and women do not.[8]

An individual's preferences are defined over their own consumption, the number of their children, and their children's income which may take the form of bequests and/or human capital. In particular, a man's preferences are represented by the following utility function:

$$u^m = \ln c + \ln[n(x+b)] \tag{1}$$

where c is his own consumption, n is the number of wives he marries (which equivalently is half the number of his children), $x \in \{1, h\}$ is the quality level (human capital) of his children, and b is the bequest per pair of children.[9] If $x = 1$, his children will grow up to be "unskilled", and if $x = h > 1$, his children will grow up to become "skilled." Thus, we assume that each woman's son and daughter are either both skilled or unskilled, although the levels of human capital and the type of human capital could differ between boys and girls. Also, we make no assumption about the distribution of bequests between a woman's two children.[10] An alternative formulation would be to explicitly specify an unequal distribution of bequests and/or level of skill investments – perhaps by giving more education to boys versus girls or by giving more bequests to the first born male (a practice called "primogeniture").[11] However, the results of the model rely only on the existence of variation within boys and girls in human capital levels (regardless of the differences in types or levels of human capital between the two sexes), and the results are robust to specifying an equal division of bequests or using a "primogeniture" rule of giving only to

[8] For reasons stated in the introduction, we do not believe that the productivity of women in the labor market can explain the decline in polygyny, since existing models suggest that increasing productivity of women in the agrarian economies leads to more polygyny. Therefore, we abstract from the issue of female labor.

[9] We follow the marriage market models of Becker (1991) and Bergstrom (1994) by making the number of wives a continuous variable. As noted by Bergstrom (1994) and Becker (1991), a fraction of a wife can be considered the expected number of years married to a wife or the fraction of men married.

[10] These assumptions imply that there are always an equal number of skilled men and women in the population, and an equal number of unskilled men and women. This serves to keep the sex-ratio within skill levels constant so that we can isolate other factors which affect the rate of polygyny and/or monogamy. In addition, this assumption implies that we are abstracting from issues concerning how marriage markets may interact with a gender bias in favor of sons or daughters. See Edlund and Lagerloff (2002) for an extensive analysis of some of these issues.

[11] See Chu (1991) and Bergstrom (1994b) who suggest that the practice of primogeniture can be used to increase the survival rate of a dynasty.

the first born son.[12]

A woman's utility function is assumed to be identical to the man's utility function, subject to the restriction that women do not choose the number of their children, which is assumed to be restricted by biological constraints and normalized to two. Therefore, a woman's utility function depends only on her consumption and the income of her two children, represented by,

$$u^f = \ln y + \ln(x + b)$$

where y is the consumption transfer (the "price") she receives from her husband, $x \in \{1, h\}$ is her children's skill level, and b is her children's bequest.

To raise skilled children, parents have to invest resources in their children's human capital. However, skilled parents are assumed to be more efficient in the production of skilled children. In other words, skilled parents have a comparative advantage in producing skilled children. Hence, if both parents are skilled, the cost for educating both of the wife's children is $\underline{e}$. If only one parent is skilled, the cost is higher and is denoted by $\bar{e}$ where $\bar{e} > \underline{e}$. If both parents are unskilled, the cost is assumed to be prohibitively high so that both children will grow up to be unskilled.

A man's income is composed of two components: labor income and non-labor income (such as land, physical capital, corruption, etc.). Labor income is determined by his human capital level, and thus is equal to h if he is skilled and 1 if he is not. In addition, non-labor income is equal to L for skilled men and λ for unskilled men. Thus, a man's total income, denoted by I, is $I = 1 + \lambda$ if the man is unskilled or $I = h + L$ if he is skilled. The income ratio between the two types of men is represented by r:

$$r \equiv \frac{1 + \lambda}{h + L}$$

Therefore, there are two sources of inequality – inequality from differences in human capital, and inequality which is due to disparities in non-labor income. In this framework, h represents the what we call the "importance" or the "value" of human capital, but more precisely, h represents both the return to human capital and the level of human capital. In this sense, h measures the importance of human capital in determining the level and distribution of income in a society.

In this general formulation, we can analyze any given level of inequality between the two types of men, and for any given level of inequality, we can analyze whether the

[12] In other words, our assumption could easily be relaxed so that the boy always gets more education, and perhaps a different type of education, than the girl. The only critical part of the assumption is that the decision to give some education to the boy is correlated with the education of the girl.

composition of inequality between the two sources of income influences the equilibrium level of polygynous matching. For the sake of simplicity, we assume that non-labor income is not distributed in a way so that unskilled men are richer than skilled men (i.e. we assume $0 < r < 1$).

Men allocate their income between their own consumption and the agreed upon level of resources transferred to each wife and her children. For simplicity, we assume that each man marries only one type of woman (skilled or unskilled), and offers identical contracts to all women within the same type.[13] Therefore, a man's budget constraint is:

$$c + n(y + \varepsilon e + b) = I \tag{2}$$

where y is the price paid to each wife, $\varepsilon = 0$ if they raise low quality children, $\varepsilon = 1$ if they raise high quality children, $e \in \{\underline{e}, \bar{e}\}$ is the cost per wife of raising quality children, and n is the number of wives he marries.

3 Analysis

An equilibrium is characterized by a set of marriage contracts which satisfy the following properties. First, men and women maximize their utility subject to their budget constraints. Second, there is no marriage contract that a man can offer to a woman that would make him better off without making the woman worse off. Third, the marriage market clears by all women getting married, which implies that two men of the same type could marry different types of women. For example, some skilled men might marry skilled women while other skilled men might marry unskilled women. In these cases, however, it can be shown that men will be indifferent between marrying one type of women or a combination of both types in equilibrium.

The optimal contract solves a maximization problem where all men and women are trying to procure their own consumption, while contracting over the amount of the resources transferred to their children – which is basically a "public good" in the sense that both parents derive utility from their children's human capital and bequests. Formally, every man offers a marriage contract, consisting of y, ε and b, to each type of woman in order to maximize his utility (1) subject to his budget constraint (2), and subject to matching alternative marriage offers for any given type of woman:

$$\ln y + \ln(x + b) \geq U \tag{3}$$

[13] As will become apparent, in equilibrium, men cannot increase their utility by offering different contracts to the same type of woman, or by marrying different types of women.

where U is the utility level of alternative marriage offers for that type of women, which is taken as given by any man. This maximization problem has to be solved for all possible combinations of contracts between types of men and women and for both levels of investment in the human capital of children.

We now establish several basic results of this model, leaving the technical derivations to the appendix. The consumption level of a skilled man is determined by:

$$c = n(y + \varepsilon e + b) = (h + L)/2 \tag{4}$$

while an unskilled man's consumption level is:

$$c = n(y + \varepsilon e + b) = (1 + \lambda)/2 \tag{5}$$

An implication of equations (4) and (5), which simplifies the analysis, is that a man's consumption level is related only to his income and not to the number and type of his wives, and not to the skill level or bequest level of his children. That is, half of a man's income is spent on consumption and half is spent on women and children.

The equilibrium "prices" (consumption transfers) for each type of woman turns out to be determined by the type of children she raises and the value of human capital in the economy. Let y_{ss} be the price for a skilled woman who raises skilled children, y_{us} is the price for an unskilled woman who raises skilled children, and μ is the price for any type of woman who raises unskilled children. These are the only prices which exist in equilibrium, and are given by:

$$\begin{aligned} y_{ss} &= \frac{h - \underline{e}}{2} \\ y_{us} &= \frac{h - \overline{e}}{2} \\ \mu &= \frac{1}{2} \end{aligned} \tag{6}$$

Therefore, a woman's consumption level is always equal to half the net value of her children's human capital. If she raises skilled children, her consumption level is half of the difference between the value of skill, h, and the cost for that household to raise skilled children ($\underline{e}$ if she is skilled and $\overline{e}$ if she is not skilled). The consumption level of a woman who raises unskilled children is also equal to half the value of unskilled human capital (normalized to equal one) minus the cost (which is zero). Thus, women always capture half of the net value of her children's human capital for her own consumption. More importantly, these results show that the value of women in the marriage market is directly linked to the quality of her children.

We now establish the equilibrium patterns of matching between the two types of men and women, and how this matching interacts with the different levels of investment in their children's human capital.

Lemma 1 *If both parents are skilled, they raise skilled children if and only if* $h \geq \underline{h}$*, where* $\underline{h} \equiv 1 + \underline{e}$*. If one parent is skilled and the other is not, then they raise skilled children if and only if* $h \geq \overline{h}$*, where* $\overline{h} \equiv 1 + \overline{e}$*.*

Lemma 1 simply states that when both parents are skilled, and thus have the lowest costs for raising skilled children, they will only do so if the value of human capital is sufficiently high. If $h = 1 + \underline{e}$, two skilled parents would be indifferent between spending $\underline{e}$ and having skilled children who will have an income of h, or spending $\underline{e}$ through a bequest and having unskilled child with an equivalent income of $1 + \underline{e}$. Therefore, when $h > \underline{h} = 1 + \underline{e}$, two skilled parents can give more income to their children for the same cost by investing in their quality rather than giving the equivalent amount as a bequest. A similar idea holds for mixed couples where one is skilled and the other is not, but the threshold level of h is higher because of the higher costs of producing skilled children. Therefore, mixed couples only have skilled children when $h > \overline{h} = 1 + \overline{e}$.

Lemma 2 *If there is an unskilled woman that raises skilled children, then all skilled women raise skilled children.*

The intuition for Lemma 2 is straightforward; skilled women have a comparative advantage in raising skilled children, so if couples where the woman is unskilled choose to invest in their children's quality, then it is also efficient for couples with skilled women to do the same. This idea is also true for couples with skilled men, as the following lemma states.

Lemma 3 *If there is an unskilled man that raises skilled children, then all skilled men raise skilled children.*

Due to the lower costs of raising skilled children, Lemmas 2 and 3 say that skilled men and women are always more likely to incur the costs of investing in their children's human capital. However, these results should not be obvious, because raising high quality children is costly, and therefore, all men face a trade-off between marrying more wives and investing in their children's quality. It turns out that although skilled men always invest at least as many resources as unskilled men in the human capital of their children, they also marry at least as many women as unskilled men.

Lemma 4 *If polygyny exists, only skilled men are polygynous.*

Lemma 4 implies that skilled men, who are richer than unskilled men, always marry at least one wife, which means that skilled men always marry at least as many wives as unskilled men. This has to be true because if one group is polygynous, the other group cannot be polygynous, since the number of men and women are equal.

Lemmas 2, 3, and 4 imply that if parents invest in raising skilled children, there will be assortative mating in the marriage market in the sense that skilled men will tend to marry skilled women. In fact, it can easily be shown that skilled women only marry skilled men in any equilibrium where $h > \underline{h}$, although some skilled men may still marry unskilled women and have unskilled children with them.

We now know that only rich (i.e. skilled) man are candidates to be polygynous. The following propositions determine the equilibrium degree of polygynous matching in the marriage market, and under what conditions monogamy is a possibility. To do this, we take as given the level of inequality, costs of human capital, and total income for each type of men (i.e. r, $h + L$, $1 + \lambda$, $\underline{e}$, and $\overline{e}$ are constant), and see how changes in the composition of inequality (i.e. changes in h as $h + L$ is held constant) determine the rate of polygyny in the marriage market. Figures 1 and 2 illustrate the following propositions by graphing the number of wives and the price of wives (the consumption transfer) when only the composition of inequality is changing. Proofs for the following propositions are derived in the appendix.

The first proposition describes the equilibrium when the value of human capital, h, is sufficiently low, so that the rich men are richer predominantly because of their non-labor income L.

Proposition 1 *If $h < \underline{h}$, then:*

(i) The degree of polygyny is independent of h.

(ii) Skilled men are polygynous.

(iii) No one invests in child quality.

This proposition states that when the return to human capital (relative to the costs) is sufficiently low, the richer men (skilled men) can afford more wives than the poorer, unskilled men. This result stems from the low value of wives in the marriage market when the value of human capital is low, making polygyny affordable for the richer, skilled men. Quality wives are inexpensive because the value of human capital is so low that even skilled men have no interest in producing quality children with skilled women, who

provide the lowest cost of producing skilled children (see Lemma 1). Since quality in children is not valued, quality in women is also not valued in the marriage market, because quality in women is valued only for helping to produce quality children. This idea is represented by equations (6), which state that the "price" of a woman (the consumption transfer to the wife) in the marriage market is directly linked to the quality of her children. Consequently, when the value of human capital is very low, women are valued only for the quantity of children they can produce, which is assumed to be identical, and not their quality. All women have equal value when no one produces quality children, and therefore, all women have identical contracts in equilibrium when $h < \underline{h}$ (depicted in Figures 1 and 2). Naturally, since there is a single price for all women, wealthier men can afford more of them in comparison to poorer, unskilled men.

Proposition 1 also states that the degree of polygyny is independent of h, implying that the rate of polygyny depends only on the level of inequality, not the composition of inequality. Again, this results from the fact that men do not care about the quality level of their wives when the value of human capital is too low to invest in child quality. So, when h is sufficiently low, rich men use their wealth to acquire "quantity" in wives and children, rather than investing in child quality. The quantity of wives that rich men can afford is determined by the uniform price for all wives in the market, which is determined by the aggregate level of income in the economy, not the different sources of income.[14] Therefore, the differences in total income between the rich and poor men determine the differences in their number of wives, and thus, the rate of polygyny. Since Proposition 1 holds the level of inequality and the incomes of both types of men constant as h changes, the degree of polygyny is constant as long as $h < \underline{h}$. Therefore, when the value of human capital is sufficiently low, polygynous behavior depends only on whether you are rich enough to afford more than one wife, and not how you got that way.

When the value of human capital is sufficiently high, however, a different pattern emerges.

Proposition 2 *If $\underline{h} \leq h < \overline{h}$, then:*

(i) The degree of polygyny declines with h.

[14] Because all women raise unskilled children and the price (the consumption transfer) is always determined by the quality of their children, the consumption transfer is independent of the level or composition of aggregate income when the value of human capital is sufficiently low ($h < \underline{h}$). However, the bequests given to each child are determined by aggregate income – so while bequests are not dependent on the composition of income in this region, they do increase with aggregate income. Thus the "full price" of a wife (the price plus the bequest plus investment in human capital) is not dependent on the composition of income in this region, but is dependent on the level of aggregate income.

(ii) Skilled men who marry skilled wives invest in child quality, while skilled men who marry unskilled wives do not invest in child quality.

Proposition 2 states that polygyny cannot be ruled out even when the value of human capital is sufficiently high to entice skilled men to raise quality children with skilled women. When the value of human capital is above $\underline{h}$, it is now efficient for skilled men to invest in child quality, but only with skilled women who have a comparative advantage in producing quality children over unskilled women (see Lemma 1). As a result, skilled and unskilled women differ in the type of children they raise when h lies within this region, so the value of skilled women in the marriage market is not identical to unskilled women (see equations (6)). Thus, skilled women are valued for the quality and not just the quantity of children they produce.

Figure 1 shows that some skilled men marry a certain number (≥ 1) of skilled women and have skilled children, while other skilled men marry a greater number of unskilled women and raise unskilled children. The reason that the latter group marries a greater number of women is because they are being compensated for lower quality with higher quantity of children. This result is enabled by the lower cost of unskilled women in equilibrium – the "full price" (the consumption transfer plus bequest level and human capital investment) is lower for unskilled women because of the low human capital of their children. However, both of these strategies must yield the same utility for any given skilled man in equilibrium. Therefore, skilled men are indifferent between choosing either the "quantity" or "quality" strategy of choosing wives and children.

Proposition 2 also states the key result of the model: the rate of polygyny depends on the composition of income and inequality, and not just the levels. Figure 1 shows that as h increases while the total incomes of skilled and unskilled men are held fixed, the average number of wives per skilled man declines. Interestingly, as h increases in this region, the skilled men who marry unskilled women and raise unskilled children marry more and more wives relative to the skilled men who go for "quality." However, there are fewer and fewer skilled men who go for "quantity" as h increases, because the value of quality is increasing with h. Thus, the skilled men who marry the unskilled women need to be compensated with more and more quantity. But, since fewer skilled men are going for "quantity," the average number of wives per skilled man declines over this region of h ($\underline{h} < h < \overline{h}$). Therefore, the rate of polygyny declines as the value of human capital increases, even after holding constant the level of income and inequality between the two types of men.

The intuition for this result stems from the increasing value of child quality, and

consequently, the increasing demand for quality in women as the value of human capital increases. The return to investing $\underline{e}$ and having a skilled child with a skilled wife is increasing with the value of human capital h. But, because skilled men will only raise skilled children with skilled women (see Lemma 1), the demand for skilled women increases relative to unskilled women as h increases within this region. Income levels are held constant throughout this exercise, so skilled men can afford fewer and fewer skilled women as their price increases with h. Thus, the rate of polygyny falls as income is determined more and more by human capital and less by non-labor income.

One way to interpret our results is the following: male inequality creates polygyny, but female inequality reduces it. As h increases, male inequality is increasingly determined by differences in human capital, and the value of quality in children also rises. As a result, the demand for quality women increases, since they are a complementary factor in the production of quality children. Thus, variation in the quality of women translates into inequality in the value of women, making it too expensive for rich men to afford multiple wives of high quality. Therefore, male inequality stemming from differences in human capital translates into inequality in the quality, not the quantity, of their wives. Becker (1991) calls this "implicit polygyny," in recognition of the trade-off in the quantity and quality of wives. Our model shows that the degree of implicit versus explicit polygyny depends crucially on the sources of male inequality – the sources of inequality determine the level of inequality in women, and therefore, the form of inequality in the marriage market. Thus, as long as male inequality persists, differences in female inequality across societies is needed to explain the mystery behind why certain societies tend towards monogamy or polygyny.

A further result of the model when $\underline{h} < h < \overline{h}$ is that there will be higher rates of assortative mating between men and women according to their skill level as h increases. This is true because the number of skilled men who marry unskilled women declines with h over this region. That is, the increasing value of skilled women causes skilled men to switch away from unskilled women. This result is consistent with the results of Fernandez, Guner, and Knowles (2001), who show that the degree of assortative matching by education levels increases with the return to human capital in advanced countries.[15] Therefore, our

[15]It should be noted that Fernandez, Guner, and Knowles (2001) restrict their analysis to developed countries which are monogamous. Interestingly, they show that the return to human capital is significant in determining how important it is for educated men to match with educated women, which implies that educated men and women do not match simply because they "have good conversation", which should be independent of the return to human capital. The fact that matching based on quality is related to the return to quality is consistent with our model.

model correctly predicts that the rate of assortative matching across quality levels of men and women will be related to the value of human capital.

Since skilled men marry fewer wives as inequality is determined more by human capital, it must also be the case that the number of wives per unskilled man increases over the region where $\underline{h} < h < \overline{h}$ (see Figure 1). This result stems from the declining demand by skilled men for unskilled women over this region, lowering the price of unskilled women and making them more affordable for unskilled men.[16] The equilibrium tends to be more monogamous as h increases over this region, but reaching a monogamous equilibrium is not guaranteed for all parameter values. A necessary condition for monogamy is that $\underline{h} < h < \overline{h}$, so monogamy cannot occur if h is too low or too high relative to the costs. The following proposition illustrates how the existence of monogamy is related to the levels of inequality within men and women.

Proposition 3 *Monogamy exists if and only if* $\overline{e} - \underline{e} \geq \frac{1-r}{r}$.

The left-hand side of the equation in Proposition (3), $\overline{e} - \underline{e}$, measures the comparative advantage of skilled women in the production of skilled children. If there were no differences in the costs of producing quality children between skilled and unskilled women, this term would be zero and all women would be equal in the marriage market, leading to polygyny. The right-hand side of the equation, $\frac{1-r}{r}$, is positively related to the level of male income inequality. In fact, this term can be re-written as $\frac{(h+L)-(1+\lambda)}{(1+\lambda)}$, which equals the percentage difference in income between skilled and unskilled men. If there is more income inequality within men, the likelihood that monogamy will characterize the equilibrium decreases.

Proposition (3) essentially states that monogamy can only exist if the comparative advantage of skilled women in producing skilled children is large enough in relation to the relative wealth of the rich men in the economy. That is, higher male inequality generates more polygyny, since rich men will use their wealth to acquire more wives and children. But, a larger comparative advantage for skilled women generates higher inequality for women in their value on the marriage market, thus making polygyny less affordable for rich men who want quality wives. So, Proposition 3 basically emphasizes our previous results: male inequality generates polygyny, while female inequality generates monogamy.

[16] The "price" for unskilled women in terms of the consumption transfer is constant over the region where $\underline{h} < h < \overline{h}$, because the value of unskilled children is constant. However, the "full price" of unskilled women includes the bequest levels, which are falling as h increases over this region. Thus, the full price of unskilled women decreases over this region, because of the declining demand for unskilled women by skilled men as h increases.

We now analyze the case where $h > \overline{h}$, however, we will argue later that this range is not likely to be relevant for the comparison between developed and less-developed countries.

Proposition 4 *If $h \geq \overline{h}$, then:*

(i) The degree of polygyny increases with h.

(ii) Skilled men are polygynous.

(iii) All skilled men invest in child quality, regardless of the skill level of their wives.

When the value of human capital exceeds $\overline{h}$, it is now efficient for skilled men to have skilled children with either skilled or unskilled women (see Lemma 1). So, when h is sufficiently high, unskilled women are also valued for the skilled children they are able to produce. Therefore, the value of skilled women in the marriage market falls relative to unskilled women when h is above $\overline{h}$. When h is below $\overline{h}$, skilled women could extract the increasing value of human capital as h increases for themselves as private consumption, because the value of their ability to produce quality children increased relative to unskilled women. This phenomenon is illustrated in Figure 2 as the prices for skilled and unskilled women diverge as h increases over the region where $h < \overline{h}$.

But, when h is above $\overline{h}$, skilled women no longer are necessary to produce skilled children, because the value of human capital is high enough so that skilled men are now willing to incur the higher costs of producing skilled children with unskilled women. In this scenario, skilled women cannot extract as much of the increasing value of human capital for themselves, because they are now more substitutable with unskilled women. Moreover, the degree of substitutability increases as h increases over the region where $h > \overline{h}$, because skilled men are more and more willing to marry unskilled women because it is increasingly efficient to do so and still have skilled children. Therefore, the comparative advantage of skilled women in producing skilled children declines as h increases, as shown in Figure 2 where the prices of skilled and unskilled women increase at the same rate, which implies that the relative price of skilled women falls with h.

Because all women are becoming more similar as h increases above $\overline{h}$, female inequality declines and polygyny increases as the full price (the consumption transfer, the bequest, and the human capital investment) falls. Essentially, the market power that skilled women have when h is below $\overline{h}$ is now transferred to skilled men – since skilled men are now the scarce resource needed to produce quality children when h is above $\overline{h}$. Thus, skilled men use their increasing bargaining power to lower the full price of all women and acquire more wives, despite the fact that only the composition of income has changed, and not the levels.

The flip side of the story is that unskilled men marry fewer and fewer women as h increases above $\overline{h}$. Intuitively, this result stems from the fact that unskilled men face increasingly stiff competition from skilled men for unskilled women, since skilled men are increasingly willing to have skilled children with unskilled women as h rises. The model assumes that it is prohibitively expensive for unskilled men to have skilled children with unskilled women, so in order to compensate unskilled women for not having skilled children, unskilled men have to increase the bequests to their children as h increases. Thus, the full price of unskilled women who have unskilled children (the consumption transfer plus bequest) is increasing over this region, making it more expensive for unskilled men to acquire a wife. Therefore, polygyny increases as skilled and unskilled men increasingly compete for the same women, and skilled men exploit their comparative advantage in producing skilled children by acquiring more and more wives.

Finally, we conclude this section by discussing how polygyny is affected by the overall level of inequality. The entire analysis in Propositions 1 - 4 held the total level of income for each group, and consequently, the level of inequality between the groups, constant as h was free to vary. At any level of h, the following proposition holds.

Proposition 5 *Given h, the degree of polygyny increases with increasing inequality (r declines).*

This proposition states that increases in inequality resulting from increasing disparities in non-labor income increase polygyny. The converse, however, is not true: increases in inequality stemming from bigger disparities in the value of human capital (i.e. r declines because h increases) will increase polygyny if $h < \underline{h}$ or $h > \overline{h}$, but polygyny may or may not increase if $\underline{h} < h < \overline{h}$. This ambiguity is due to two effects opposing effects: (1) an increase in inequality tends to make men more polygynous, and (2) an increase in the composition of wealth derived from human capital decreases polygyny. Therefore, the total effect on polygyny depends on which effect dominates. All of these results together show that the degree of polygyny is dependent not only on the level of inequality, as emphasized in the existing literature, but also the composition of inequality. Both of these factors determine whether male inequality manifests itself as inequality in the number of their wives, or the quality of their wives.

4 Implications of the Model

4.1 Is polygyny bad for growth?

Inferences from the model about growth are straightforward using standard assumptions about the relationship between growth and the accumulation of human and physical capital. All of the results presented in the previous section are true for any level of aggregate human capital in the economy, represented by the proportion of skilled individuals in the economy, θ. However, the proportion of skilled individuals in the next period will depend on the value of human capital h and the costs of producing human capital ($\overline{e}$ and $\underline{e}$).

If h is lower than $\underline{h}$, then the return to human capital (relative to the costs) is too low for even skilled men to invest in child quality with skilled women. Thus, the next generation will consist of no children with high human capital. Even rich families will invest minimal resources in the quality of their children, leading the economy to converge to a low aggregate level of human capital. In addition, because rich men will tend to spend their income on multiple women and children, the amount of physical capital leftover for each child will also diminish over time. If we assume that growth is dependent on the accumulation of physical and human capital, we can infer that economies in the first region of Figure 1 will find it very hard to break out of the poverty trap if polygyny allows the wealthier men to use their income to acquire quantity rather than quality women and children. That is, polygyny can be considered an "engine of decline" for countries with low levels of human capital, because polygyny allows rich men to spend their money on quantity rather than investing in child quality (in the form of physical or human capital investment in each child).

If, however, countries with low h enforced a ban on polygyny, the ban will prevent rich men from spending their income on quantity, and force them to invest in quality. It can be shown that an enforced ban on polygyny in the first or second regions of Figure 1 ($h < \overline{h}$) will result in higher bequests per child, thus allowing for a faster accumulation of physical capital which should lead to higher values of human capital, assuming that physical and human capital are complements in the production process. Thus, a strictly enforced ban on polygyny in countries with sufficiently low h could help lead the economy to grow and develop to the point where h grows further into the second region of Figure 1 ($\underline{h} < h < \overline{h}$), where the rate of polygyny declines with h. In this sense, an enforced ban on polygyny could help the economy grow and develop to the point where polygyny naturally declines with growth – possibly to the point where the equilibrium becomes monogamous

and the ban would be superfluous.

If the economy is in the third region of Figure 1 ($h > \overline{h}$), skilled men are marrying multiple skilled and unskilled women and having skilled children with both types. Rather than spending their money just on quantity, rich men in this region use their income to produce quality children with multiple wives. As a result, the proportion of skilled people will increase over time, generating economic growth. Therefore, polygyny at very high values of human capital can actually be considered an "engine of growth," since polygyny acts as the "technology" which allows skilled men to multiply their type at a high rate. If polygyny was effectively banned in this economy, the proportion of skilled people would remain constant over time (θ is constant).

Over time, h is likely to converge to the second range of Figure 1 ($\underline{h} < h < \overline{h}$) if the return to skill is determined in the labor market by its marginal product and there is some degree of complementarity in the aggregate production process between skilled and unskilled workers. Suppose $h < \underline{h}$, then no one will invest in high quality children, and therefore, the return to quality would rise so that h will increase to a level above $\underline{h}$. On the other hand, h larger than $\overline{h}$ implies that the supply of skilled workers increases over time, reducing the return to skill until the economy reaches a steady-state in which h is no longer larger than $\overline{h}$. Thus, h is likely to be of intermediate values ($\underline{h} < h < \overline{h}$) in any steady state.

4.2 Why are developed countries more monogamous than less-developed countries?

In the context of the model, we can think of a developed country as having a high value of human capital h relative to the costs of producing human capital ($\overline{e}$ and $\underline{e}$) compared to poorer countries. As discussed above, h represents both the return and the level of human capital. Thus, in developed countries, h can be associated with a college degree whereas an unskilled worker can be associated with a high school dropout. In a poor economy, in contrast, h can represent a worker who graduated elementary school, and an unskilled worker is literate at most. Under this interpretation, h is likely to be larger in advanced countries. But, one might also think that the cost of becoming skilled is higher in advanced economies. However, the ratios of h to $\overline{e}$ and $\underline{e}$ are likely to be higher in the advanced economy, because parents with higher levels of human capital are more effective in producing quality children (see Moav (2001)).

Therefore, assuming that economies typically lie within the second region of Figure

1 ($\underline{h} < h < \overline{h}$) for reasons stated above, h in poorer countries is likely to be closer to $\underline{h} = 1 + \underline{e}$, while h in richer countries is likely to be closer to $\overline{h} = 1 + \overline{e}$. According to Proposition 2, this implies that richer countries should be more monogamous, since inequality is determined more by differences in human capital, while inequality in poorer countries is determined more by differences in non-labor income (land, physical capital, corruption, etc.).[17] As a result, male inequality in poorer countries tends to manifest itself as inequality in the number of wives per man, while male inequality in advanced countries translates into higher inequality in the quality of wives per man.

An alternative approach for comparing developed to less-developed countries would be to examine differences in the proportion of rich men who are rich because of their human capital versus rich men who are wealthy because of their non-labor income. That is, we could extend the model to allow for two types of rich men, and developed countries would be characterized by having a greater proportion of rich men who acquire their wealth through human capital. In this framework, it is straightforward to show that the rate of polygyny would decline with development (i.e. with increases in the proportion of rich men who are skilled), as predicted by the current setup of the model.

4.3 What about laws and norms against polygyny?

It may be tempting to explain the mystery of monogamy by pointing to explicit bans and informal norms against polygyny in advanced societies. However, banning polygyny does not guarantee the absence of polygynous behavior. Sometimes bans on polygyny appear to be binding, as in most Western countries, but in many cases these bans are ineffective and unenforced, as seen by persistently high rates of polygyny in many undeveloped countries including those in Western Africa (see the analysis in the next section). The problem with banning polygyny is that it is almost impossible to enforce: the state can decide not to recognize polygynous marriage, but it is not easy to stop consenting adults from living together and having children. Banning the formal institution of polygynous marriage does not necessarily eliminate polygynous behavior, which is the subject of this paper.

Consequently, we follow Becker (1991) who argues that bans on polygyny in richer countries only seem to be effective because there is little demand for polygynous behavior. It is hard to imagine that many men in the United States would become polygynous if the laws against polygyny were suddenly repealed. However, it is tempting to think that

[17] The overall level of inequality is usually higher in poorer countries, so this may also contribute to their higher rates of polygyny (see Lagerlof (2002)). Also, see footnote 1 in the introduction for evidence that inequality is more dependent on human capital in advanced countries.

this is explained by informal norms against polygyny. But, norms are similar to laws in that they are unlikely to be followed if the cost of doing so is high. Elster (1989) argues that while "social norms can act as a restraint on rationality," it is also true that "rationality acts as a constraint on social norms." So, even if social norms do constrain polygynous behavior, it is difficult to imagine that norms have nothing to do with economic incentives, and yet are so correlated with economic development, investments in child quality, assortative mating between high quality husbands and wives, and increasing power for women within the household and in society. In addition, we demonstrate in the next section that polygynous behavior is correlated with economic variables within religious groups in the same geographic area of Cote d'Ivoire, where norms concerning polygyny should be constant. Thus, our model should be seen as an attempt to explain why rational incentives for monogamy are much stronger in advanced countries, and therefore, these stronger incentives most likely interact with social norms to reinforce each other in order to create a more monogamous equilibrium.

One might also argue that men would not become polygynous in modern societies if polygyny were legalized because women would never want to be in a polygynous marriage. Again, this is likely to be explained by norms which are reinforced by rational incentives. Looking at what women "want" or demand is only half of the story. It is hard to imagine that women in less-developed countries want or demand fewer resources in the marriage than women in advanced countries. Our model shows why women are valued as a cheap commodity in poor countries, while the value of quality women in rich countries drives up their status and bargaining power to the point where polygyny is very expensive. Therefore, our model explains why women in advanced countries tend to receive more in equilibrium based on rational behavior, and this tendency likely contributes to the creation of social norms – which reinforce each other to create stronger "preferences" for monogamy in advanced countries.

To be more specific, our model can be used to show why laws and norms against polygyny emerge in advanced economies within a political economy framework. Becker (1991) points out that, in contrast to conventional wisdom, women are not the ones necessarily harmed by the practice of polygyny. In principle, polygyny does not force women into polygynous marriages, it only keeps the option open for them, and therefore, increases their value in the marriage market.[18] In many cases, women will prefer to be the second

[18]Posner (1992) also makes this point, but points out that women in polygynous societies may not have the option to be in a monogamous marriage if the man can always marry more women later. Posner states, however, that this problem is often solved with marriage contracts which can force the man to

wife of a wealthy man who can provide for her and her children over a poor man who cannot. So, the people who really suffer from polygyny are actually poor men, who may face very dim marriage and reproductive prospects if they have to compete with rich men in a polygynous market. Higher rates of polygyny, therefore, are likely to be associated with increasing social unrest stemming from a larger mass of frustrated poor men.

In a simple model where rich men control a disproportionately large influence over laws and social norms, it is unlikely that rich men will create laws or norms which are very costly to themselves relative to the political benefits. So, when rich men naturally have a low demand for polygynous behavior, they will tend to placate the lower classes by banning polygyny (formally or with informal norms) and making marriage more accessible to the masses. That is, in advanced countries, the political economy gains for rich men of giving the "benefit" of monogamy to poorer men outweighs the rather small costs of limiting themselves to only one wife, which our model predicts is already the equilibrium tendency. But, in poorer countries, our model shows that the cost of limiting themselves to one woman is very high, and therefore, the rich and powerful are likely to keep this privilege for themselves and deal with the potential wrath of the lower classes in other ways. Thus, the political economy equilibrium is reinforced by the magnitude of the demand for polygyny by the rich men in the society, which our model shows is dependent on the value of human capital.

Finally, to see how norms and private incentives can interact and reinforce each other, consider the ban on polygyny by the Christian Church. The ban on polygyny was one of many sexual reforms by the Church which took time to be effective (see Posner (1992) and Betzig (1992, 1995)), most likely due to the high demand for polygyny prior to the increase in the importance of human capital. However, economic growth likely triggered a positive feedback between investments in human capital, the natural growth of monogamy, and a more effective ban on polygyny. In this manner, social norms and rational incentives can interact with economic growth to reinforce each other and create an advanced, highly monogamous economy.

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live up to a monogamous commitment. Bergstrom (1994a) clarifies who is hurt by polygyny further by showing that monogamy benefits women who marry wealthy men and it hurts the rest of the women who marry poorer men.

5 Empirical Evidence

The purpose of this section is to provide empirical support for the main assumptions and conclusions of the model. While this is not a formal test or estimation of the model parameters, a model of monogamy and polygyny should be consistent with the patterns in the data. Many of the predictions of the model are already supported by existing evidence. For example, the model predicts that monogamy should be correlated with richer countries where income depends more on labor versus non-labor income.[19] The model is also consistent with higher rates of assortative mating based on education levels when the return to human capital is higher (Fernandez, Guner and Knowles (2001)). In addition, the model predicts that wives should be more expensive in monogamous societies, which is exemplified by the roughly equal division of household resources in marriages in modern societies. To provide further evidence, this section uses data from Cote d'Ivoire to show that the model is remarkably consistent with the mating and reproductive patterns of men and women within a society exhibiting large variation in polygynous behavior.

The analysis uses the CILSS data from Cote d'Ivoire in 1986. The data consists of a sample of households and contains information on each member of the household. While polygyny is formally outlawed in Cote d'Ivoire, the practice of polygyny is rampant, which illustrates the futility of banning polygyny when the demand for polygyny is high. Forty-one percent of all women between the ages of 18 and 40 are in a polygynous marriage, and this figure ranges from twenty-four percent for Catholic women to sixty-two percent for Muslim women. Table 1 presents sample statistics for male heads of households, and confirms that higher rates of polygyny are found within the Muslim community. However, polygyny is still prevalent within the Christian community (27% of Catholic men) and within the big city of Abidjan (15% of all men). Our empirical strategy will examine whether economic variables can explain variation in individual marriage decisions within religions, cities, and regions.

The main inference of the model is that polygyny depends not only on the level of a man's income, but also on the sources of his income. This result is examined in Table 2 where a probit is estimated for the probability that a man has more than one wife (i.e. practices polygyny). The analysis controls for the geographic location of residence (dummy variables for living in the big city of Abidjan or "Other Cities", and three regional dummy variables for living in the East Forest, West Forest, and Savannah), religion (dummies for

[19] See Footnote 1 for evidence.

being either Muslim, Catholic, Protestant, Other Christian, Animist, or Other Religion), and age (dummy variables for each ten-year interval).

Table 2 confirms the basic result of the model by showing that total income is positively associated with being polygynous, but higher levels of education and/or wage income are associated with lower rates of polygyny. This result is true if education is entered by itself, with wage income, or with the percentage of total income represented by wage income. In addition, dummy variables for being self-employed in agriculture, self-employed in business, and being a wage earner are included in the specification. So, these findings are not simply picking up the effect of being a farmer versus a wage earner. Overall, the results show that richer men have more wives, but controlling for total wealth, men who earn their money through education and labor income have fewer wives. This result confirms the main prediction of our model: polygynous behavior is associated not only with the level of income, but also the sources of income.

A second prediction of the model is that men who are wealthy because of their non-labor income will tend to squander their money on multiple women of lower quality, while educated men will tend to marry an educated woman and have educated children. The first column of Table 3 supports this prediction by showing that women in polygynous marriages tend to have lower levels of education. The second column controls for the education of the husband, and shows that educated men tend to marry educated women. The second column also shows that polygynous men marry less educated women, even after controlling for the man's education. These results are all conditional on controlling for the woman's age, religion, and place of residence. Overall, Table 3 confirms an important prediction of the model: higher quality women will tend to be the single wife of a high quality man, while low quality women will tend to be one of the multiple wives of a low quality (but wealthy) man.

Another major implication of the model is that educated men prefer educated women in order to produce more educated children. To examine this issue, Table 4 regresses the education level of children on the characteristics of their parents. The results show that the education levels of both the mother and father are significant determinants of the child's education level - higher educated parents have higher educated children, even after controlling for household income. These findings are consistent with an important implication of the model: the components of income, in addition to the level, are important determinants of investing in child quality. These results are consistent with higher quality parents having a comparative advantage in producing higher quality children. Furthermore, Table

4 shows that children in polygynous households are less educated, even after controlling for parental education and household income. Therefore, educated men are using their income to acquire fewer high quality women in order to produce higher quality children, while wealthy men with lower human capital are using their wealth to acquire more lower quality wives and children.

Table 5 closes out the analysis by showing that polygynous households have more children after controlling for household income and parental education. Interestingly, parental education negatively affects the number of children, but the mother's education level seems to be more statistically significant than the father's education.[20]

Overall, the data from Cote d'Ivoire reveal many patterns which are consistent with the implications of the model. Although polygyny is banned, the ban is clearly not binding. The analysis reveals an underdeveloped country which is struggling to escape poverty because polygyny allows men with high levels of non-labor income to squander their wealth on multiple women of low quality and raise many low quality children. However, these tendencies are reduced very significantly if the man's wealth is derived from education or wage income rather than non-wage income. Therefore, all of these results confirm the main implication of the model: polygynous mating is related to the sources of income and inequality, and not just the levels. Furthermore, the analysis demonstrates that norms are not the entire explanation for the existence of polygyny or monogamy: variation in polygynous behavior is found *within* various social groups, defined by religion and location of residence. This variation is explained with variation in the sources of income and human capital, which confirms the predictions of our model and the importance of purely economic incentives in determining the prevalence of polygyny versus monogamy.

6 Conclusion

This paper uses standard assumptions regarding preferences and the production of human capital to explain why modern societies are less polygynous than less-developed societies. The model explains why men in less-developed economies prefer quantity over quality in wives and children, and derives the marriage market equilibrium which allows them to afford multiple wives. The explanation is rather intuitive. Rich men in less-developed

[20] For polygynous households, the analysis in Table 5 uses the average education of wives in the household because the regressions are performed at the household level, and therefore, the education level of multiple wives in polygynous households had to be aggregated to a household measure. For monogamous households, the average education level of all wives is simply the education level of the mother.

economies are not efficient at producing quality children because they tend not to have high human capital themselves. Therefore, they have a low demand for quality children, and consequently, a low demand for quality women who can help them produce quality children. As a result, women in less-developed societies are valued only for the quantity of children they can produce, and not the quality. This makes all women very close substitutes for one another, which keeps the price of all women low enough for richer men to acquire multiple wives.

In more advanced economies, richer men tend to have high human capital, and therefore, they are more efficient at producing human capital in children. This creates a high demand for quality in children and in women, because quality women are complements in the production of high quality children. Thus, all women are not close substitutes in the marriage market in advanced societies. Higher quality women are a scarce resource, which drives up their price in the marriage market and makes polygyny is less affordable for wealthy men.

The results, therefore, can be summarized as follows: male income inequality generates polygyny, but female inequality reduces it. Moreover, the model shows how female inequality is generated, as the value of women in the marriage market is directly determined by the net value of her children's human capital. So, naturally, when human capital has a high value, women who can create high quality children more efficiently are increasingly valued in comparison to low quality women. Thus, the value of human capital is directly related to the value of women in the marriage market, which also helps to explain why and how the "power of women" increases within the family and in society in economies with higher values of human capital. In this manner, the model is consistent with the roughly equal division of resources between husbands and wives in modern marriages.

In addition, the results of the model are consistent with the observed strong correlation between development and monogamous practices, as well as the correlation between higher assortative mating and higher returns to human capital. Furthermore, our analysis using data from Cote d'Ivoire shows that after controlling for total income, men with higher education levels and higher labor incomes marry fewer wives and have fewer children, both of which tend to be more educated. That is, men who get rich because of their human capital tend to go for quality rather than quantity in both their wives and children. These results confirm the main prediction of the model: the sources of income and inequality, and not just the levels, determine the degree of polygyny in the marriage market.

Finally, we conclude by discussing the policy implications of our results. The most

obvious policy instrument is a ban on polygyny, which we argue could help lead to more growth and development if it is enforced. However, it will be difficult to enforce if the demand for polygynous behavior is strong, in particular because polygyny is typically beneficial for rich men who tend to wield disproportionate political and social power. If, however, the demand for polygyny by rich men is naturally weak because of the high value of human capital, then laws and norms against polygyny are more likely to evolve because they are reinforced by economic incentives. A second policy instrument is a simple subsidization of education. The subsidy will not only have a direct effect of encouraging increasing investments in education, but will also have an indirect effect of encouraging monogamy – since the higher net value of education will increase the payoff of investing in quality women and children. In turn, increasing monogamy can help create or reinforce a monogamous norm, which then leads to more investments in child quality and more growth and development to follow.

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7 APPENDIX

This appendix presents additional notation necessary for the analysis of the marriage market, derives the optimal marriage contracts and the general equilibrium, and provides proofs for the lemmas and propositions.

7.1 Notation

A marriage contract offer consists of a price, y, the skill level of the children, x, and a bequest level for the children, b. A pair (y_{ij}, b_{ij}) denotes the offer that a *skilled man* is making to a woman with skill level $i \in \{s, u\}$ to have children of skill level $j \in \{s, u\}$, where s and u denote skilled and unskilled respectively. For example, y_{us} denotes the price offer of a skilled man to an unskilled woman proposing to raise skilled children. Similarly, n_{ij} denotes the number of women that a skilled man marries, where i is the type of woman and j is the skill level of their children.

As we show below, in equilibrium, unskilled men offer marriage contracts only to unskilled women to have unskilled children. Hence, we denote by μ and b_l the price and bequest, respectively, that an *unskilled man* offers to an unskilled woman to raise unskilled children, and by v the number of wives an unskilled man marries.

7.2 The properties of the optimal marriage contract

Every man offers y, ε and b to maximize (1) subject to (2) and (3). (In equilibrium, equation (3) holds with equality.) Substituting these equations into (1) yields:

$$Max\{\ln[I - n(\frac{U}{x+b} + \varepsilon e + b)] + \ln[n(x+b)]\}.$$

There are three alternatives for investments in child skill; (i) $\varepsilon = 0$, $x = 1$; (ii) $\varepsilon = 1$, $x = h$, and $e = \underline{e}$; or (iii) $\varepsilon = 1$, $x = h$, and $e = \bar{e}$.

Case (i) : If $x = 1$ and $\varepsilon = 0$, the first order conditions are:

$$\begin{aligned} \frac{\frac{U}{1+b} + b}{I - n(\frac{U}{1+b} + b)} &= \frac{1}{n} \\ \frac{n\frac{U}{(1+b)^2} - n}{I - n(\frac{U}{1+b} + b)} &= -\frac{1}{1+b} \end{aligned}$$

Rearranging and using (2) and (3) with equality yields for a woman of type $i \in \{s, u\}$:

$$\begin{aligned} y_{iu} &= \frac{1}{2} \\ c &= n(y_{iu} + b_{iu}) = \frac{I}{2} \end{aligned} \tag{7}$$

Case (ii) : If $x = h$, $\varepsilon = 1$ and $e = \underline{e}$, the first order conditions are:

$$\begin{aligned} \frac{\frac{U}{h+b} + \underline{e} + b}{I - n(\frac{U}{h+b} + \underline{e} + b)} &= \frac{1}{n} \\ \frac{n\frac{U}{(h+b)^2} - n}{I - n(\frac{U}{h+b} + \underline{e} + b)} &= -\frac{1}{h+b} \end{aligned}$$

Rearranging and using (2) and (3) with equality yields:

$$\begin{aligned} y_{ss} &= \frac{h - \underline{e}}{2} \\ c &= n_{ss}(y_{ss} + \underline{e} + b_{ss}) = \frac{I}{2} \end{aligned} \tag{8}$$

Case (iii) is the same as case (ii) except that $e = \bar{e}$, yielding:

$$\begin{aligned} y_{us} &= \frac{h - \bar{e}}{2} \\ c &= n_{us}(y_{us} + \bar{e} + b_{us}) = \frac{I}{2} \end{aligned} \tag{9}$$

7.3 Proof of Lemma 1

Consider a couple composed of two skilled parents, and let x and b denote the skill and bequest levels, respectively, that are specified in their contract. Recall that their cost of raising skilled children is $\underline{e}$ and the difference in income between skilled and unskilled children is $h - 1$. Let $h - 1 < \underline{e}$. Hence, if $x = h$, then $x + b$ can be increased without affecting c and n by setting $x = 1$ and increasing b by $\underline{e}$. Therefore, if $h - 1 < \underline{e}$, $x = h$ is not optimal and cannot be an equilibrium.

Suppose that $h - 1 > \underline{e}$ and the contract specifies $x = 1$. In this case, $x + b$ can be increased without affecting c and n by setting $x = h$ and reducing b by $\underline{e}$. Hence, if $h - 1 > \underline{e}$, $x = 1$ cannot be an equilibrium. Whenever $h = \underline{e} + 1$, parents are indifferent between $x = 1$ and $x = h$, in which case we assume that they raise skilled children. Thus, we have shown that if both parents are skilled, they raise skilled children if and only if $h \geq \underline{h}$.

If only one parent is skilled, the cost of raising a skilled children is $\bar{e}$. We can use the same argument to show that if one parent is skilled and the other is not, they raise skilled children if and only if $h \geq \overline{h}$. That completes the proof of Lemma 1.

7.4 Proof of Lemma 2

Suppose the contrary is true: there is at least one unskilled woman that raises skilled children and a skilled woman that raises unskilled children.

It is easy to show that, in equilibrium, women within each type attain the same utility level. Between types, there are two alternatives: (1) unskilled women have at least the same utility as skilled women or, (2) skilled women have strictly greater utility. Let us examine each alternative.

Alternative 1: Since it takes at least one skilled parent to raise skilled children, there must be at least one skilled man that raises skilled children with an unskilled woman. If so, a skilled man who offered (y_{us}, b_{us}) could make instead the same offer, $(y_{ss}, b_{ss}) = (y_{us}, b_{us})$ to a skilled woman that had unskilled children and raise skilled children. He saves $\bar{e} - \underline{e}$ and she attains the utility level of the unskilled woman, which, in this alternative, is at least as high as her own. Thus, he strictly gains and she does not lose, which could not exist in equilibrium.

Alternative 2: Let z satisfy the condition that $\ln z + \ln(1 + b_{su}) = \ln y_{us} + \ln(h + b_{us})$, and recall that in this alternative $\ln y_{su} + \ln(1 + b_{su}) > \ln y_{us} + \ln(h + b_{us})$. Hence,

$$\ln z + \ln(1 + b_{su}) = \ln y_{us} + \ln(h + b_{us}) < \ln y_{su} + \ln(1 + b_{su})$$

and it follows that $z < y_{su}$.

Consider a man that offers the contract (y_{su}, b_{su}). He could improve on it by offering to an unskilled woman a contract of (z, b_{uu}) with $b_{uu} = b_{su}$. He is better off because he saves $y_{su} - z > 0$, and she receives the same utility since by the definition of z, $\ln z + \ln(1 + b_{uu}) = \ln z + \ln(1 + b_{su}) = \ln y_{us} + \ln(h + b_{us})$, implying that this alternative cannot exist in equilibrium.

Thus, we have ruled out the two alternatives, which proves the lemma.

7.5 Proof of Lemma 3

The cost of raising skilled children for unskilled men is at least $\bar{e}$. Hence, if an unskilled man raises skilled children then by Lemma 1 it must be that $h \geq \overline{h}$. However, by Lemma 1, if $h \geq \overline{h}$, skilled men find it optimal to raise skilled children with either skilled or unskilled women, proving the lemma.

7.6 Proof of Lemma 4

Consider first the case in which skilled and unskilled men raise unskilled children and denote by v the number of wives that each unskilled man marries. Then by equation (7)

the consumption price of women is 1/2 regardless of the man's type. Since men value all women identically, their children receive the same level of bequest. Hence, equations (4) and (5) imply that $n_{iu} = \nu/r > \nu$, proving the lemma for this case.

Now, consider the case where at least some skilled men raise skilled children, and assume by contradiction that unskilled men are polygynous, implying that some unskilled men marry skilled women. There are two alternatives: (i) Skilled women that marry unskilled men raise unskilled children or (ii) they raise skilled children.

In Alternative (i), it must be that skilled women are indifferent between marrying skilled men and raising skilled children and marrying unskilled men and raising unskilled children. Hence, by (7) and (8),

$$\ln\left(\frac{h-\underline{e}}{2}\right) + \ln(h + b_{ss}) = \ln\left(\frac{1}{2}\right) + \ln(1 + b_{su}).$$

Due to Lemma 1, it must be that $h \geq \underline{h} = 1 + \underline{e}$, so it follows that $\frac{h-\underline{e}}{2} \geq \frac{1}{2}$, and therefore, $h + b_{ss} \leq 1 + b_{su}$.

On the other hand, since at least some skilled men raise skilled children it follows that:

$$n_{ss}(h + b_{ss}) \geq n_{su}(1 + b_{su}) = \frac{v}{r}(1 + b_{su}) > v(1 + b_{su})$$

where the equality stems from (4) and (5). Hence, since $h + b_{ss} \leq 1 + b_{su}$, it follows that $n_{ss} > v$, and the lemma is proved for Alternative (i).

Consider Alternative (ii). By Lemma 1 it must be that $h \geq \overline{h}$. Because some unskilled men marry more than one unskilled woman it follows from (5) and (7) that $b_l < \lambda/2$, where b_l denotes the bequest offer of the unskilled man. Hence, a skilled man could offer to one unskilled woman with unskilled children $y_{us} = 1/2$ and $b_{us} = b_l + 1 - h$. She is indifferent between the two options and he gains from it because he marries one woman and raises educated children. This offer is feasible for him as:

$$\frac{h+L}{2} - (y_{us} + \bar{e} + b_{us}) = \frac{h+L}{2} - \frac{1}{2} - \bar{e} - b_l - 1 + h \geq 0$$

where the inequality stems from the fact that $h \geq \overline{h} = 1 + \bar{e}$, and $L/2 > \lambda/2 > b_l$. Hence, it cannot be that skilled men marry less than one woman each and that concludes the proof of the lemma.

7.7 Proof of Proposition 1

Since $h < \underline{h}$, Lemma 1 implies that all men raise unskilled children. In that case, men are indifferent between skilled and unskilled women and we denote by n_{iu} the number of

women (of either type) that a skilled man marries. Hence, (4) and (5) yield,

$$\frac{v}{n_{iu}} = r \tag{10}$$

Since, in equilibrium, all women marry,

$$\theta n_{iu} + (1-\theta)v = 1$$

Substituting into (10) yields:

$$n_{iu} = \frac{1}{\theta + (1-\theta)r} \tag{11}$$

which proves parts (i) and (ii) of the proposition. Part (iii) follows immediately from Lemma 1, thus completing the proof.

7.8 Proof of Proposition 2

Part (ii) follows from Lemma 1. It remains to prove (i).

Suppose that there is polygyny and let $\overline{h} \leq h < \overline{h}$. By Lemmas 1 and 4, some skilled men marry skilled women and raise skilled children and the rest marry unskilled women and raise unskilled children. Since skilled men must be indifferent between the two options, it follows that:

$$\ln c + \ln[n_{ss}(h + b_{ss})] = \ln c + \ln[n_{uu}(1 + b_{uu})]$$

and since by (4), c is the same in both cases, it follows that:

$$n_{ss}(h + b_{ss}) = n_{uu}(1 + b_{uu}) \tag{12}$$

On the other hand, it follows from (4) and (5) that:

$$n_{ss}(y_{ss} + \underline{e} + b_{ss}) = (h + L)/2 \tag{13}$$

$$n_{uu}(y_{uu} + b_{uu}) = (h + L)/2 \tag{14}$$

and,

$$\nu(\mu + b_l) = (1 + \lambda)/2 \tag{15}$$

Let p denote the proportion of skilled men that marry unskilled women. By Lemmas 1 and 4 and because all women marry:

$$\theta p n_{uu} + (1-\theta)\nu = 1 - \theta \tag{16}$$

and,

$$\theta(1-p)n_{ss} = \theta \tag{17}$$

Finally, since unskilled women are indifferent between skilled and unskilled men (in both cases they raise unskilled children), it must be that:

$$\mu(1+b_l) = y_{uu}(1+b_{uu}) \tag{18}$$

Solving (4), (5), (7), (8), and (12) - (18) yields,

$$p = \frac{(1-\theta)[1-(h-\underline{e})r]}{1+\theta(h-\underline{e}-1)} \tag{19}$$

Substituting (19) into (17) yields n_{ss} :

$$n_{ss} = \frac{1+\theta(h-\underline{e}-1)}{(h-\underline{e})[\theta+(1-\theta)r]} \tag{20}$$

Equations (12)-(14), (19), and (20) imply,

$$n_{uu} = n_{ss}(h-\underline{e}) = \frac{1+\theta(h-\underline{e}-1)}{\theta+(1-\theta)r} \tag{21}$$

Finally, we define the "degree of polygyny" as the average number of women that a rich (skilled) man marries. Thus, from (19)-(21), the degree of polygyny is:

$$\begin{aligned} pn_{uu} + (1-p)n_{ss} &= \frac{(1-\theta)[1-(h-\underline{e})r]}{1+\theta(h-\underline{e}-1)} \frac{1+\theta(h-\underline{e}-1)}{\theta+(1-\theta)r} + 1 \\ &= \frac{1-(1-\theta)(h-\underline{e}-1)r}{\theta+(1-\theta)r} \end{aligned} \tag{22}$$

which is declining with h, thus completing the proof of the proposition.

7.9 Proof of Proposition 3

It follows from (20) that n_{ss} is declining with h and reaches $n_{ss} = 1$ at $h = h^* \equiv \frac{1}{r} + \underline{e}$, at which point, by (19), $p = 0$. Note that (20) holds for $\underline{h} \leq h \leq \overline{h}$. Hence, there is monogamy if $\underline{h} \leq h^* \leq \overline{h}$ which is the case if $\frac{1}{r} + \underline{e} \leq \bar{e} + 1$. Hence, monogamy exists if $\overline{e} - \underline{e} \geq \frac{1-r}{r}$.

Suppose that $\overline{e} - \underline{e} < \frac{1-r}{r}$. In that case it follows from (20) that $n_{ss} > 1$ for all $h \leq \overline{h}$. Hence, to complete the proof, it remains to rule out monogamy when $h > \overline{h}$.

Let $h > \overline{h}$, and assume by contradiction that there is monogamy. If follows from Lemma 1, (4), and (8) that:

$$b_{ss} = \frac{h+L}{2} - \frac{h+\underline{e}}{2}$$

and a skilled man's utility is:

$$U_1 = \ln\left(\frac{h+L}{2}\right) + \ln\left(h + \frac{h+L}{2} - \frac{h+\underline{e}}{2}\right) = \ln\left(\frac{h+L}{2}\right) + \ln\left(\frac{h+L}{2} + \frac{h-\underline{e}}{2}\right)$$

Since each unskilled man marries one unskilled woman, and by (7) pays her 1/2, it follows from (5) that they leave no bequest to their children. Thus, her utility is $\ln \frac{1}{2} + \ln 1$.

Hence, an educated man could offer an unskilled woman the contract $(y_{us} = 1/2, b_{us} = 1 - h)$, making her indifferent between the two alternatives. By (4), this contract implies that $n_{us} = \frac{h+L}{2}(\frac{1}{2} + 1 - h + \bar{e})^{-1}$ and his utility, U_2 under this contract, increases since:

$$\begin{aligned} U_2 - U_1 &= \frac{h+L}{2(\frac{1}{2}+1-h+\bar{e})} - \left(\frac{h+L}{2} + \frac{h-\underline{e}}{2}\right) \\ &= \frac{h+L}{2}\left(\frac{1}{\frac{1}{2}-(h-1-\bar{e})} - 1\right) - \frac{h-\underline{e}}{2} \\ &\geq \frac{h+L}{2} - \frac{h-\underline{e}}{2} > 0 \end{aligned}$$

where the inequality follows from the fact that for $h \geq \overline{h}$, $\frac{1}{\frac{1}{2}-(h-1-\bar{e})} \geq 2$. Hence, the alternative contract strictly increases the man's utility without reducing the woman's utility which cannot be true in equilibrium, completing the proof.

7.10 Proof of Proposition 4

It is shown in the proof of Proposition 3 that there is polygyny if $h > \overline{h}$. This result, along with Lemma 4, prove (ii). Part (iii) follows directly from Lemma 1.

>From Lemma 1 and parts (ii) and (iii), all skilled men have skilled children, some with skilled women, and the others with unskilled women. Since they must be indifferent between the two options, and by (4) and 5,

$$n_{ss}(h + b_{ss}) = n_{us}(h + b_{us})$$

$$n_{ss}(y_{ss} + \underline{e} + b_{ss}) = (h + L)/2$$

$$n_{us}(y_{us} + \bar{e} + b_{us}) = (h + L)/2$$

$$\nu(\mu + b_l) = (1 + \lambda)/2.$$

Since unskilled women are indifferent between raising skilled children with skilled men and raising unskilled children with unskilled men,

$$\mu(1 + b_l) = y_{us}(h + b_{us}).$$

Finally, since all unskilled women get married,

$$\theta p n_{us} + (1 - \theta)\nu = 1 - \theta.$$

These equations together with (7) - (9) and (17) yield

$$n_{ss} = \frac{1}{1-p} \tag{23}$$

$$n_{us} = \frac{h - \underline{e}}{(h - \bar{e})(1-p)} \tag{24}$$

$$p\theta \frac{h - \underline{e}}{(h - \bar{e})(1-p)} + \frac{(1-\theta)r}{(h - \bar{e})^2 \left(\frac{(1-p)}{h - \underline{e}} - k\right) - k} = 1 - \theta \tag{25}$$

where $k = (h+L)^{-1}$. Since the derivative of the left hand side of (25) is positive with respect to p and negative with respect to h, it follows that dp/dh is positive. That, together with (23) and (24), prove part (i), completing the proof of the proposition.

7.11 Proof of Proposition 5

For $h \leq \overline{h}$, Proposition 5 follows immediately from (11) and (22). To prove the proposition for $h > \overline{h}$, note that the derivative of the left hand side of (25) is positive with respect to p and to r. Hence, higher inequality (lower r) increases p. By (23) and (24), n_{ss} and n_{us} are positively correlated with p, therefore, it follows that the proposition holds also for $h > \overline{h}$.

Figure 1a

Polygyny as a function of the value of human capital: Average number of wives of a high income men.

The figure is plotted for the case where the condition in Proposition 3 is satisfied and monogamy exists.

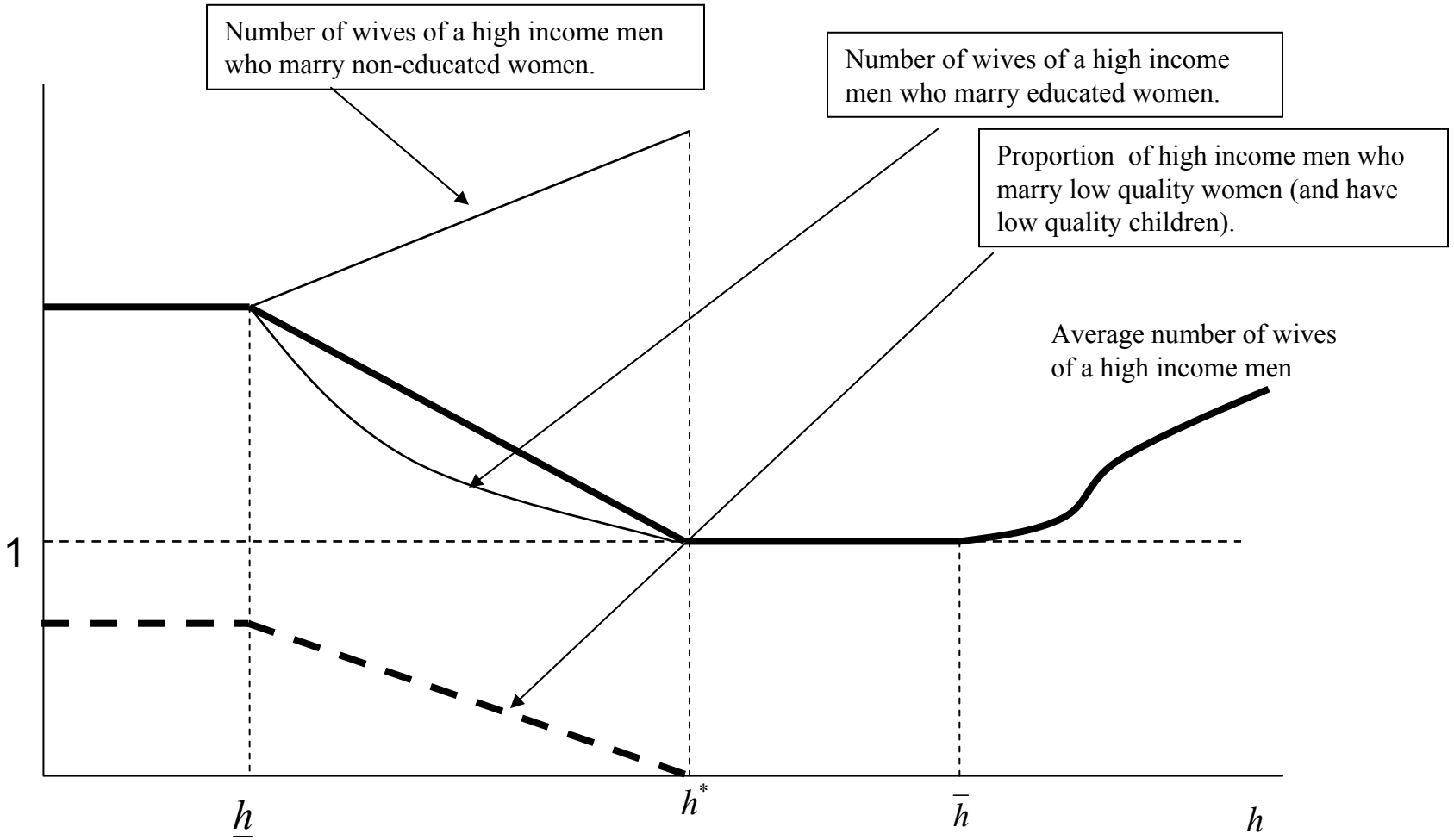

Figure 1b

Polygyny as a function of the value of human capital: Average number of wives of a high income men.

The figure is plotted for the case where the condition in Proposition 3 is not satisfied and monogamy does not exist.

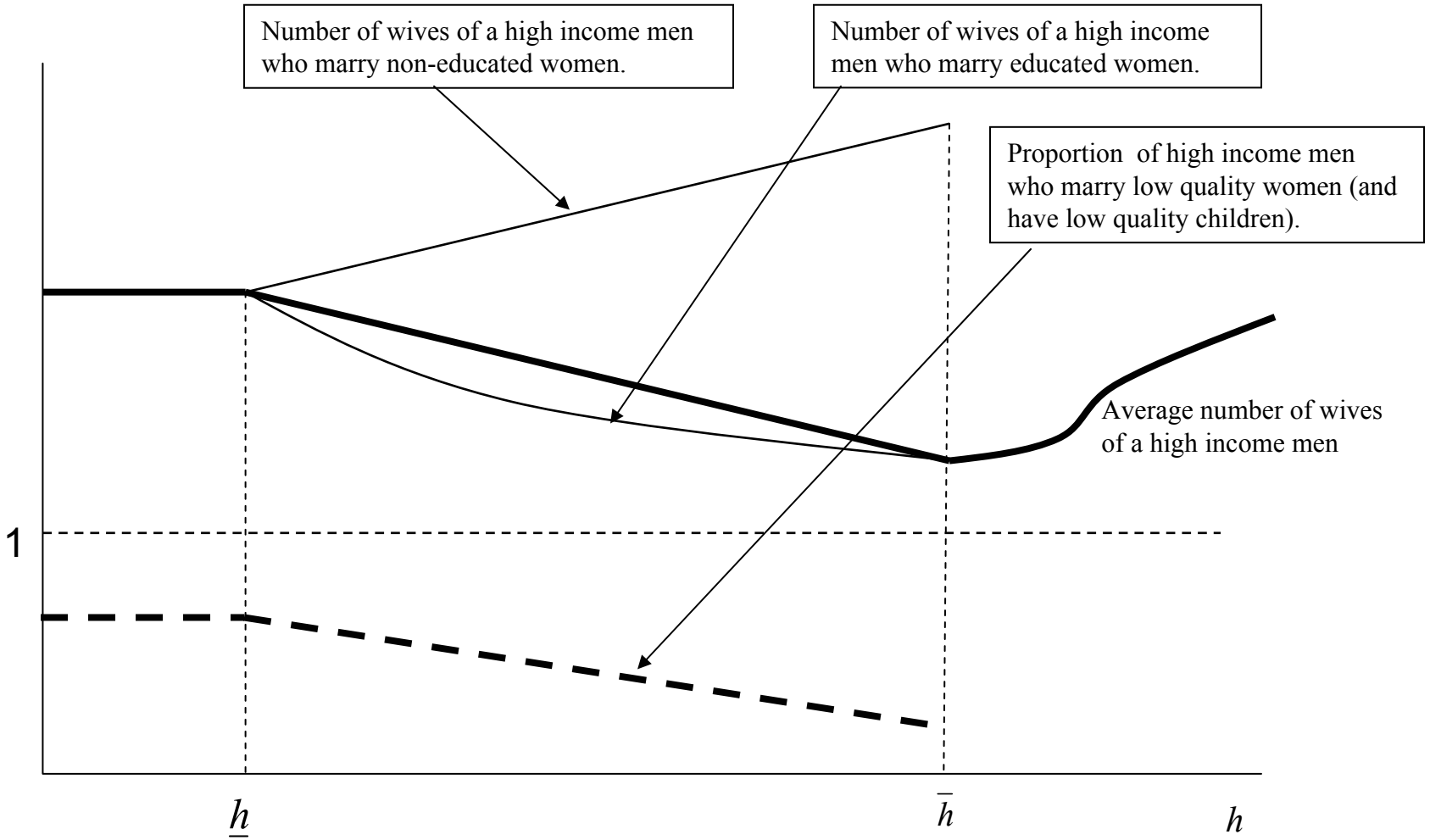

Figure 2

"Consumption Prices" for Both Types of Women as a function of the value of human capital.

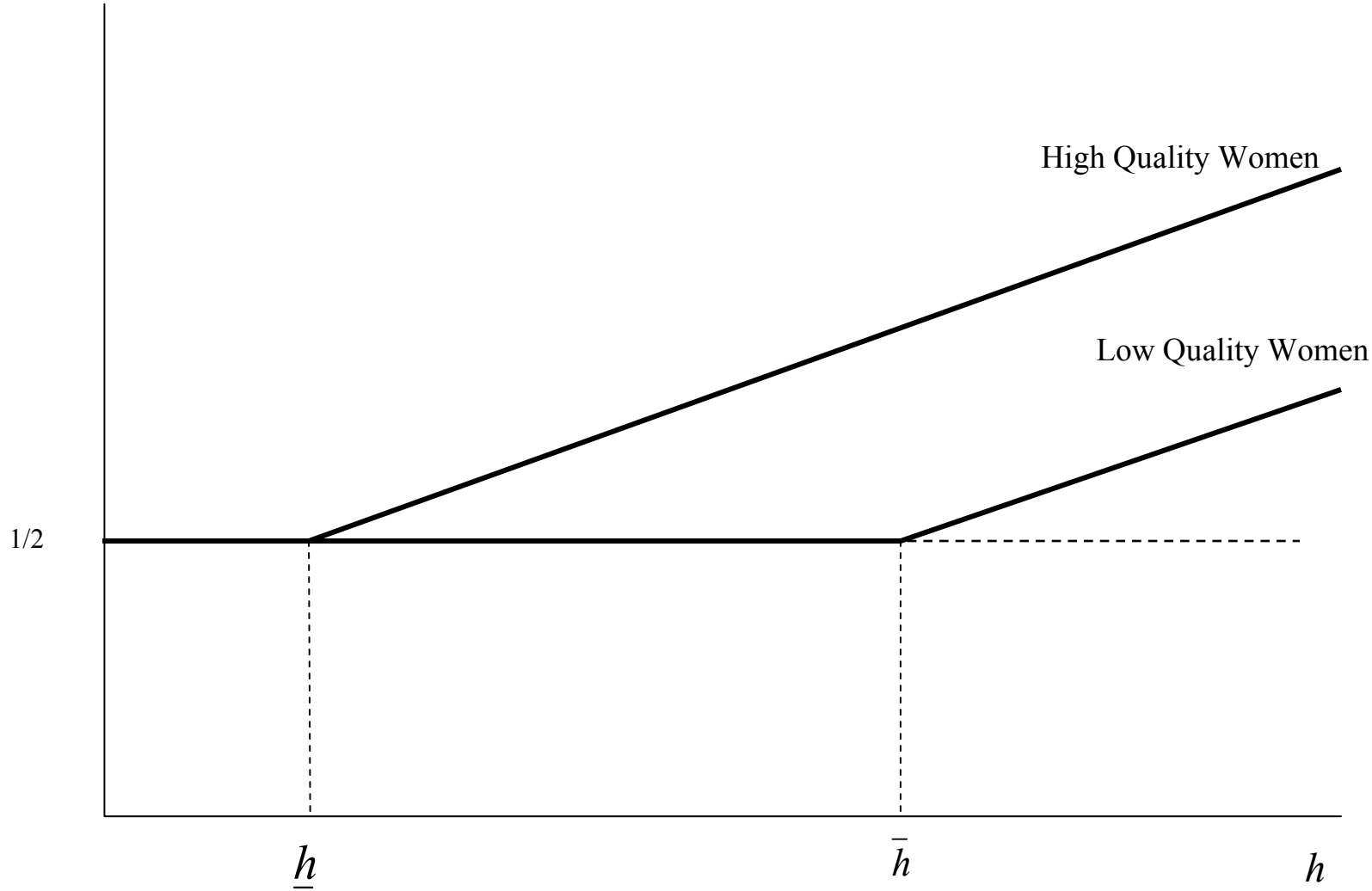

Table 1: Summary Statistics for Male Heads of Households in Cote D'Ivoire, 1986

	Mean	Std. Deviation
Polygyny Dummy Variable		
All Men	0.30	0.46
Muslim Men	0.42	0.49
Anamist Men	0.32	0.47
Catholic Men	0.18	0.38
Protestant Men	0.19	0.39
Other Christian Men	0.23	0.42
Other Religion Men	0.16	0.37
Religion Dummies		
Muslim	0.34	0.47
Anamist	0.25	0.43
Catholic	0.27	0.44
Protestant	0.05	0.23
Other Christian	0.04	0.20
Other Religion	0.03	0.18
Geographic Dummies		
City of Abidjan	0.21	0.41
Other Cities	0.22	0.41
East Forest Region	0.23	0.42
West Forest Region	0.15	0.36
Savannah Region	0.19	0.39
Income and Education Variables		
Total Personal Income	1,388,546	1,591,037
Personal Wage Income	446,907	1,193,002
Years of Education	3.16	4.86
Works for wages	0.24	0.43
Self-Employed in Agriculture	0.51	0.50
Self-Employed in Business	0.13	0.34
Sample Size	1360	

The sample includes all male heads of households between the ages of 21 and 70.

Table 2: Probability of Being Polygynous, Male Heads of Households

	Probit: Dependent Variable =1 if man has more than one wife				
Total Personal Income	0.063 (0.010)	0.108 (0.013)	0.055 (0.009)	0.110 (0.013)	0.066 (0.009)
Education	-0.018 (0.004)			-0.009 (0.005)	-0.015 (0.005)
Personal Wage Income		-0.165 (0.026)		-0.148 (0.027)	
Percent of Total Income from Wages			-0.368 (0.087)		-0.302 (0.088)
Age Dummies	Yes	Yes	Yes	Yes	Yes
Geographic Dummies	Yes	Yes	Yes	Yes	Yes
Religion Dummies	Yes	Yes	Yes	Yes	Yes
Dummies for Self-Employed in Agriculture, Business, and being a Wage Earner	Yes	No	No	Yes	Yes
Observations	1357	1358	1358	1357	1357

Coefficient estimates are the marginal effects from the probit results. Standard errors are in parentheses. The income and wage variables have been normalized by dividing by one million, and were created by subtracting the estimated annual income of non-heads of the household from the "created" variables for total household income and total household wage income. Age dummies include the following categories: below 25, 25-34, 35-44, 45-54, 55-64, and greater than 64. The five geographic and six religion dummies are detailed in Table 1. The sample includes all male heads of households between the ages of 21 and 70.

Table 3: Explaining the Education Level of Wives

	OLS Regression Dependent Variable: Education Level of the Wife	
Dummy for being in a Polygynous Marriage	-0.646 (0.125)	-0.271 (0.103)
Education level of the Husband		0.427 (0.015)
Age Dummies	Yes	Yes
Geographic Dummies	Yes	Yes
Religion Dummies	Yes	Yes
R-square	0.31	0.54
Number of observations	1710	1709

Standard errors are in parentheses. The explanatory variables have been defined in Tables 1 and 2.

Table 4: Explaining the Education Level of Children

	OLS Regression			Probit		
	Dependent Variable: Education Level of the child			Dependent Variable = 1 if child has any education, 0 otherwise		
Number of Wives in Household	-0.115 (0.031)	-0.042 (0.034)	-0.054 (0.032)	-0.050 (0.014)	-0.032 (0.016)	-0.030 (0.015)
Father's Total Income	0.105 (0.018)	0.039 (0.021)	0.044 (0.019)	0.053 (0.009)	0.040 (0.011)	0.035 (0.010)
Father's Education		0.050 (0.011)	0.049 (0.010)		0.023 (0.005)	0.025 (0.005)
Mother's Education		0.048 (0.015)			0.021 (0.008)	
Mean Education of all Wives in Household			0.046 (0.013)			0.020 (0.007)
Male	0.294 (0.054)	0.313 (0.058)	0.296 (0.054)	0.108 (0.024)	0.108 (0.027)	0.109 (0.025)
Age Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Religion Dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.50	0.50	0.52			
Observations	2225	1909	2186	2225	1909	2186

Standard errors are in parentheses. The sample is restricted to children between the ages of 5 and 12. Age dummy variables are included for each age within this range. The income variable has been normalized by dividing by one million.

Table 5: Explaining the Number of Children in Households

	OLS Regressions		
	Dependent Variable: Number of Children in the Household		
Number of Wives in Household	2.040 (0.099)	2.023 (0.099)	1.991 (0.119)
Father's Total Income	0.188 (0.051)	0.218 (0.056)	0.230 (0.062)
Father's Education		-0.029 (0.023)	0.018 (0.030)
Mean Education of all Wives in Household			-0.113 (0.038)
Age Dummies	Yes	Yes	Yes
Geographic Dummies	Yes	Yes	Yes
Religion Dummies	Yes	Yes	Yes
R-Squared	0.38	0.38	0.32
Observations	1358	1357	1203

Standard errors are in parentheses. The sample is restricted to households with a male head between the ages of 21 and 70. The income variable has been normalized by dividing by one million. The analysis uses the average education of wives in the household because the regressions are performed at the household level, and therefore, the education level of multiple wives in polygynous households had to be aggregated to a household measure.

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