Demographic Transition in Africa: The Polygyny and Fertility Nexus

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Abstract

Sub-Saharan Africa is the only region of the world where the demographic transition is not about to be completed. Though mortality has declined since the 1960s, fertility remains very high. We examine the role played by the common practice of polygyny in sustaining a high level of fertility in this region. We find that polygyny has opposite effects on individual and aggregate fertility. A woman married to a polygynous man tends to have fewer children than if she is the only wife. However, the practice of polygyny increases the number of marriages, resulting in higher aggregate fertility. Furthermore, fertility is contagious, whereby a woman, regardless of whether she is married to a monogamous or a polygynous man, tends to produce more children as fertility level in her neighborhood, proxied by polygyny prevalence, increases. We estimate these distinct effects using household data. These estimates further allow us to simulate the impact of polygyny on total fertility in sub-Saharan African countries.

Keywords: Polygyny, fertility, contagion, sub-Saharan Africa

JEL Classification: J12, J13

1 Introduction

African population has remarkably increased since the 1950s, reaching one billion in 2009. This demographic growth has been mostly concentrated in sub-Saharan Africa, where population has been growing at an average rate of 2.5 percent in recent years. Northern Africa, with an average growth rate of less of 2 percent, has contributed less to this demographic boom. Fertility and mortality have declined in both regions, but these declines have been comparatively slower in sub-Saharan Africa. As shown by Figure 1, while average total fertility was about 7 children per woman in the early 50s in both regions, it has declined to just above the replacement level at 2.5 children per woman in 2009 in Northern Africa, versus 5 children per woman in sub-Saharan Africa. Similarly, the infant mortality rate has declined from about 200 per thousand to 25 per thousand in the former region versus 100 per thousand in the latter. Northern Africa initiated its demographic transition in the early 70s, whereas sub-Saharan Africa began its own only in the 90s. One wonders while fertility has remained so high in this latter region, despite an unprecedented improvement in child survival and education.

[Insert Figure 1]

In this paper, we argue that the common practice of polygyny in sub-Saharan Africa has played a major role in sustaining a high level of fertility in this region. This argument draws on Cahu, Fall and Pongou (2012) who propose a theoretical model of how polygyny affects individual and aggregate fertility behavior. [1] They consider a society where men may marry several wives, while women may only have one husband. In this model, agents derive utility from having children as well as from other consumption goods. The number of children is a source of prestige to their parents, so that having more children while others have less, generates more satisfaction. Under the assumption that the husband, acting as a rational social planner, allocates (i) children across his wives; and (ii) other goods across his wives and himself, this model exhibits the following predictions, useful for our analysis:

(1) The total number of children that men have increases with their number of wives, while the number of children that women have may increase or decrease with their number of co-wives.

[1] The model in Cahu, Fall and Pongou (2012) relies on the fidelity matching model developed in Pongou (2009a; 2009b) and Pongou and Serrano (2009; 2013).

(2) Fertility is contagious in the sense that the number of children that a woman has is positively affected by that of other women in the society.

(3) At the societal level, the practice of polygyny positively affects aggregate fertility by directly increasing the number of marriages.

(4) As a corollary of (2) and (3), any individual, whether involved in a monogamous or a polygynous relationship, tends to produce more children as the prevalence of polygyny in his/her neighborhood increases, which basically reflects the contagious effect of fertility in more polygynous societies.

It follows that polygyny may have opposite effects at the individual and aggregate levels. At the individual level, a woman who is married to a polygynous man competes with her co-wives for the man's attention and resources. This, under certain natural assumptions, causes her to produce fewer children than she would have if she were the only wife. This prediction follows the assumption that the number of children that each wife delivers is proportional to her own resources plus the husband's resources split evenly across all spouses. As the number of wives increases, each receives a smaller amount of resources from their husband, implying fewer children. This negative effect of polygyny on female fertility at the individual level holds as long as the marginal value of children is not too high compared to that of other consumption goods, or if the amount of resources allocated to the latter goods is fixed. When the marginal value of children is relatively high, polygyny positively affects female fertility.

At the aggregate level, however, polygyny mechanically increases the number of marriages. This leads to higher aggregate fertility comparatively to what would prevail in a monogamous culture. It is shown in Cahu, Fall and Pongou (2012) that this result holds even when polygyny negatively affects female fertility at the individual level, as long as the total demand for wives is smaller than the number of unmarried women on the marriage market. But this latter condition is practically always satisfied, as empirical data show that even in settings where polygyny is legal, some women still remain single.

The contagious effect of fertility stems from the social prestige that children bring to their parents. As an individual's neighbors produce children, the relative "prestige rank" of that individual decreases, giving him an incentive to produce even more offspring to maintain his social status. This effect amplifies individual fertility levels in societies where polygyny is highly prevalent. This is because in such societies, exposure to polygynous men and to their relatively large number of children incites even monogamous men to produce more children than if they had had only monogamous neighbors.

We empirically test Propositions (1) - (4) above using the Demographic and Health Surveys (DHS) from twelve sub-Saharan African countries (Benin, Cameroon, Ghana, Côte d'Ivoire, Madagascar, Malawi, Nigeria, Rwanda, Senegal, Tanzania, Uganda and Zimbabwe).[2] These household surveys are representative at the national and subnational levels. They contain information on the practice of polygyny, family structure, fertility history, and a wide range of other demographic and socio-economic variables for households and individuals. Analyzing these data, we provide empirical evidence of the impact of polygyny on fertility at the individual and aggregate levels. Our estimates indicate that women in polygynous unions have fewer children than their counterparts in monogamous unions, except in two countries (Uganda and Côte d'Ivoire) where the effect is positive. Also, women residing in areas where polygyny is more prevalent do have more children, supporting the claim that proximity with polygynous families and their high fertility stimulates the desire of children both in polygynous and monogamous individuals. The analysis further shows that polygyny increases the frequency of unions; and leads to higher aggregate fertility levels. Finally, we simulate the effect of polygyny on aggregate fertility for all sub-Saharan African countries for which data are available.

The remainder of this chapter is organized as follows. Section 2 briefly surveys the literature on demographic transition, and how it relates to polygyny. Section 3 provides empirical evidence linking polygyny and fertility, and Section 4 shows simulations of the different effects of polygyny on fertility at the macro level in the sub-Saharan African countries for which data are available.

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

2 Demographic transition, fertility and polygyny

2.1 The classic drivers of the demographic transition

Traditionally, the demographic transition begins with a decline in mortality while fertility remains persistently high, which leads to a regime of high population growth. A fall of fertility follows, driving back population growth to a new stationary regime characterized by low fertility and mortality (Chesnais, 1992). The demographic transition is considered a powerful force that induces the transition to modern economy (see Galor and Weil's (1999; 2000) unified growth model). For this reason, the factors that cause fertility to decline, have been extensively studied by demographers and economists (see Galor (2005; 2010) for a survey of this literature; Shapiro (2011)). Some have argued that the decline in mortality is a major factor in fertility decline (see Nerlove (1974); Kalemli-Ozcan (2002); Dyson (2010)). However, the fact that in Western Europe, mortality started declining nearly a century prior to the fall of fertility has cast doubt on this explanation. Based on data from England during the period 1861–1951, Fernandez-Villaverde (2001) and Doepke (2005) argue that lower mortality was probably not the main driver of the fertility decline.

The rise of income has also been advanced as another driver of the fertility decline (Becker (1960)). Female labor force participation increased with industrialization, driving up the opportunity costs of bearing children. Jones and Tertilt (2006), for instance, document a strong negative relationship between fertility and income at the individual level in the USA between 1826 and 1960. This hypothesis, however, may not be consistent with the fact that Western European countries simultaneously experienced their demographic transition during the nineteenth century, although they had significantly different levels of income per capita. Also, using a panel of countries during the period 1870–2000, Murtin (2009) showed that income per worker was positively correlated with fertility rates, independently of the effects of mortality and education.

The other potential trigger of the fertility decline is the generalization of education. According to Galor and Weil (1996), the industrial revolution increased the demand for human capital and female labor, increasing income and relaxing household budget constraints, and allowing parents to invest more in their children's human capital (see also Galor and Weil (1999; 2000); Galor and Moav (2002)). The increasing returns to human capital then led to a preference for quality over quantity of children, igniting the decline in fertility (see also Becker *et al* (1990); Tamura (1996); Galor and Weil

(2000); De La Croix and Doepke (2003)). Murtin (2009) also showed that investment in education was a dominating force in the decline in fertility. Supportive evidence has also been provided by Murphy (2009) in the case of France and Doepke (2004) for England.

2.2 Delayed demographic transition in sub-Saharan Africa

In spite of a steady decline in mortality, sub-Saharan African countries are still experiencing high population growth rates, as fertility started to decline only in the early 80s (see Figure 1). This delay in the second phase of the demographic transition is a puzzle, especially considering the unprecedented progress made in education and health.

[Insert Figure 2]

Female education tends to decrease fertility through delayed unions, more frequent use of contraceptive, and better care of children resulting in lower mortality. As shown by Figure 2, fertility and female education (measured by years of schooling) are clearly negatively correlated, regardless of the period considered. It is therefore likely that recent improvements in educational levels are in part responsible for the small decline in fertility observed since the late 1980s in sub-Saharan Africa. However fertility rates have remained much higher than expected in this part of the world. Although this delay in the demographic transition could be partially explained by the excess infant mortality due to civil wars and the consequences of the AIDS epidemic (Cahu and Fall (2011)), the huge increase in education witnessed by this region implies that the fall in fertility should have been more pronounced. Indeed, according to Murtin (2009), when average schooling improves from 0 to 10 years, fertility should at the same time decrease by about 50 to 80 percent. We did not see that happen in sub-Saharan Africa. This justifies the need to look beyond the classic determinants of fertility decline, and motivates our focus on the role played by polygyny.

The economics of polygyny was pioneered by Gary Becker (1974; 1981) and Amyra Grossbard (1978). These studies focused on the effects of polygyny on the marriage market and economic productivity. A stream of papers based on micro data from Côte d'Ivoire later found that the development of polygyny is linked to female productivity (e.g., Jacoby, 1995). As shown by Figure 3, polygyny is quite common in sub-Saharan Africa, although its incidence has been declining over time.

Polygyny had long been suspected to positively affect fertility in African countries. Muhsam (1956) and Dorjahn (1959) were among the first to document the role of polygyny in fertility behavior. Recent studies have focused on specific Senegalese ethnicities (see, e.g., Lardoux and Van de Walle (2003); Borgerhoff Mulder (1989)).

[Insert Figure 3]

Other studies have analyzed the impact of polygyny on fertility and economic development. Tertilt (2005) argues that polygyny might be negatively related to economic development as competition for wives in a polygynous society increases the price of brides, diverting savings from investment in physical capital. This study also notes that polygyny increases the incentive to have more children as fathers are entitled to collect the dowry on behalf of their daughters. In subsequent studies, Tertilt (2006) and Schoellman and Tertilt (2006) show in a calibrated model that changes in marriage laws and women's property rights regarding polygyny may have positive impacts on economic growth. By increasing the number of unions, polygyny may offset part of the beneficial effects of education (also see Lambert and Behaghel (2011)). These analyses underscore the role that polygyny may play in fertility behavior in sub-Saharan Africa.

We do not know of any study that has analyzed the effect of polygyny on individual and aggregate fertility in a unified framework. Our study therefore fills this gap in the literature. In particular, we show that polygyny negatively affects female fertility at the individual level in most countries, but has a positive effect on aggregate fertility, as shown by Figure 4. We also find that fertility is contagious, which further amplifies the effect of polygyny in sub-Saharan Africa. Moreover, simulating the effects of polygyny on fertility clearly shows the magnitude of its impact in each country.

[Insert Figure 4]

3 Empirical analysis of the link between polygyny and fertility

3.1 Descriptive statistics

Polygyny is practiced in almost all of the 49 countries of sub-Saharan Africa. However, we limit our analysis to a dozen of countries. Nuptiality and fertility are likely to vary both over time and with age. To disentangle those two dimensions, the links between polygyny and fertility should be studied in a given area at different points in time. We therefore retain only countries for which at least three waves of the Demographic and Health Surveys (DHS) are available. This selection reflects the diversity in both legal status and actual practice of polygyny. Our sample contains the four countries where laws related to polygyny have been modified; polygyny has been legalized in Malawi (2004) and abolished in Benin (2004), Burundi (1993) and Côte d'Ivoire (1964). To these countries, we add countries where polygyny has remained legal (Cameroon, Senegal, Ghana, Rwanda, Tanzania, Zimbabwe, Uganda). As Madagascar is the only country where polygyny is totally prohibited and where three waves of the DHS surveys are available, we also include it in the sample.

Legal reforms are not good instruments of the actual practice of polygyny. Although some countries have enacted laws to ban polygyny or to allow it, changes in legislation tend to follow the evolutions of customs rather than the contrary. Difficulties faced by countries passing laws to ban polygyny (such as Uganda or Kenya) or trying to enforce them (as in Senegal[3]) illustrate that reality.

The DHS have information on marital status polygyny. A woman is considered to be "involved in a relationship" if she claims either to be married or to be "living together" with a man. Polygyny is then defined as whether a woman involved in a relationship declares that her husband "has more than one wife". This definition of polygyny is thus based on self-declaration, and is not strictly dependent of the legal forms that marriage take in different countries. Moreover only about 0.03 percent of married women and 0.05 percent of unmarried women do not know whether their partner has another wife. Polygyny is about 18 percent higher among married woman than among unmarried woman involved in a relationship. All in all, the incidence of polygyny computed here is unlikely to be significantly either overestimated or underestimated.

Table 1 below displays some average statistics for the various countries of our sample. Polygyny appears to be very frequent, and is more widespread in Western Africa than elsewhere on the continent. Respectively 42 percent and 46 percent of women in a relationship in Senegal and Benin, are involved with a polygynous man versus less than 20 percent of the women in Eastern Africa. The percentage of women involved in a relationship (either married or not) ranges from 49 percent in Rwanda to 83 percent in Tanzania. As the share of women formerly married is also high, it

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

appears that staying single is a relatively rare condition in sub-Saharan Africa. Women also tend to marry young: most of them wed before 20 years of age in all the countries. This custom certainly plays a role in increasing fertility as women tend to be more fecund in their early adulthood and have more time to try having children.

[Insert Table 1]

Infant mortality[4] is still very high in this sample of countries, reaching 73.8 in Malawi and 69.3 in Tanzania. It is affected by contextual factors, such as environment or the availability and quality of health services, but depends on individual factors as well. To gauge the chances of survival of children at the individual level, one may think to use the actual mortality rate among the children born to a woman. However, such a statistics is strongly endogenous. As the number of children born is a discrete variable, that takes only a limited number of values; the *actual* mortality rate is a poor predictor of the *theoretical* probability of death of a woman's child, especially for women with a small number of children. However, one can exploit the information of actual mortality to infer infant mortality rates at the individual level by using a Bayesian method (see Cahu *et al* (2012) for details). This estimate is built so as to be similar for all children of the family.[5]

3.2 Polygyny and fertility at the micro level: a first estimation

We use a regression-based analysis to determine whether competition amongst spouses of a polygynous man increases or decreases fertility, as predicted by the theory (see Cahu *et al* (2012)). We estimate the effects of polygyny on the total number of children born, whether they are still alive or not using individual-level data. This estimation is conducted for each country separately based on the sample of women currently involved in a relationship. This estimation may be jeopardized by the fact that women entering a marriage with a polygynous man may be selected. To address this issue, we introduce several controls such as education, the length of marriage, the number of marital unions in which a woman has been involved, and dummy variables indicators for religion, region of residence, and location (urban/rural). We also control for health status, using the projected infant mortality rate at the individual level, average regional mortality rates and a dummy indicator for

[4] The number of child deaths before one year of age per 1000 births.

[5] In practice, women who have complications in their first pregnancy are more likely to have complications in subsequent ones and probability of death may not be totally independent of the rank of the child in the family.

fecundity. Although the number of children is a discrete variable, we use ordinary least squares regressions to facilitate the interpretation of results.

We estimate the following model:

$$\nu_m^{i,j} = \gamma^j \pi^i + X^i \beta^j + \alpha^j t + \varepsilon^i \quad (1)$$

where $\nu_m^{i,j}$ denotes the number of children of a married woman i living in a country j, π^i a binary variable indicating whether i is married to a polygynous man, with characteristics X^i a vector of observable individual-level characteristics, and t a linear yearly trend.

Estimations results are reported in table 2. It appears that apart from Côte d'Ivoire and Uganda, the practice of polygyny has a significant negative impact on fertility, controlling for the duration of marriage. The latter variable increases fertility in each of the countries included in the sample. Average infant mortality in a region[6] increases fertility as well. The Bayesian estimate of the probability of death of a child at the individual level is in general positively correlated with fertility.

That women in polygynous relationships tend to have fewer children is consistent with the theoretical prediction in Cahu *et al* (2012). It is also consistent with the observation of Timaeus and Reynar (1998) that the number of women without children in polygynous unions is high see also Pison (1986) and Pebley and Mbugua (1989)). Other explanations of this effect have been suggested: (i) Polygyny may be seen as a way to compensate for longer post-partum or breast-feeding periods, which decreases the likelihood of a subsequent pregnancy soon after birth. (ii) Also, the age of the husband could have a significant impact on fecundity, as most polygynous unions tend to match younger women with much older men, although male fecundity tends to decline with age, as documented by Garenne and van de Walle (1989) and Lardoux and van de Walle (2003). (iii) Very early marriage common among women married to polygnists may result in physiological infertility, causing lower fertility in older ages. (iv) Finally, additional wives in a polygynous union are often much younger than first wives and the large age difference with their husband may reduce fertility of co-wives.

[Insert Table 2]

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[6] We use the average regional infant mortality estimated for the year in which women had their first child or for the year in which they turned 20 if they do not have children.

3.3 Contagious fertility: The effect of regional-level polygyny

In this section, we identify the contagious effect of fertility, using regional-level polygyny as a predictor of regional-level or neighbors' fertility. More precisely, we show that women living in regions with high prevalence of polygyny tend to produce more offspring than their counterparts living in low-prevalence regions. To estimate this effect, we pool data for all the selected countries.

Using the largest subnational division in the DHS, we compute the prevalence of polygyny and other social characteristics in 140 geographical areas *r*. (see Appendix A for all the surveys used in this exercise). Doing so at different points in time using the several rounds of survey, we obtain averages for 559 region-survey years, whereby the average number of individuals in each region-survey year is 650. For each region *r* and survey year *t*, we compute aggregate statistics by averaging individual characteristics as follows (where $k = (r, t)$):

$$y_t^r = y^k = \frac{1}{\#k} \sum_{i \in k} y^i \qquad (2)$$

The descriptive statistics are reported in Table 3. π^k is the average prevalence of polygyny, h^k the average years of schooling, and R_b^k the shares of the population affiliated with the main religions *b* in each region-survey year k.

[Insert Table 3]

The contagious effect of regional-level polygyny of a woman's fertility is estimated based on the following equation:

$$\nu_m^{i,k} = \pi^i \gamma^j + X^i \beta^j + \pi^k \zeta + Y^k \theta + t\alpha^j + \varepsilon^i \qquad (3)$$

where Y^k is a vector consisting of religion and schooling characteristics at the regional level, and θ the effects of these latter variables. The contagious effect of polygyny on fertility is given by the coefficient ζ. We use OLS regressions to estimate equation (3). Results are reported in table 4.

The results show that regional-level polygyny increases individual fertility. Infant mortality, both at the regional and individual levels also appears to be highly correlated with fertility. The contagious effect of polygyny decreases after the duration of union is controlled for. We also note that although polygyny is correlated with religious norms, education and infant mortality, it has an independent effect on fertility in both polygynous and monogamous households. This finding validates our theoretical prediction.

It is also to be noted that estimating separately the effect of regional-level polygyny on fertility for married and unmarried women does not significantly change the results. First, the reduction in fertility which occurs among polygynous unions is larger for unmarried women. Second, polygyny has larger contagious effects on fertility when occurring among unmarried than married women. An explanation of that phenomenon would necessitate a theoretical model and a specific analysis of microeconomic data that fall beyond the scope of this article.

[Insert Table 4]

One could argue that household income interacts with both fertility choices and polygyny, leading to biased estimates of the effects of polygyny on fertility when income is not controlled for. Household income is not directly reported in the DHS surveys. However several determinants of income such as the husband's employment status, education level and occupation are available. When adding regional averages of all those variables in the vector Y^k of equation (3), the estimated contagious effect of polygyny increases about 25 percent. This may be explained by the fact that more productive husbands tend to be more educated. Moreover polygyny is more frequent in individuals in labor intensive occupations such as farmers and salesmen where larger family is an asset but in which per capita income is not among the highest. Consequently, the omission of income is likely to induce a downward bias on the effect of polygamy on fertility.

3.4 Effects of regional-level polygyny on marriage and remarriage

In this section, we estimate the effect of polygyny on marriage. We analyze the probability of being involved in a relationship using a Probit model (Equation (4)). We assume that this probability depends on individual- (X^i) and regional-level characteristics (Y^k), as well as polygyny prevalence (π^k). Individual characteristics include a woman's age, education level and proxies for health status through high and low body mass indexes[7] and fecundity status. We also control for the

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[7] Women with BMI indexes below 17.5 and above 25.5 tend to have fewer children than average women all other things equal, while the number of children they desire is on the contrary higher than the ones desired by average women. This contradiction suggests that low and high BMI values indicate physiological limitations to fertility.

average regional level of education, which proxies collective female empowerment. Religion dummies are also controlled for. We estimate the following equation using a probit model:

$$p_n = \Phi\left(X^i \beta_n + \pi^k \zeta_n + Y^k \theta_n\right) \tag{4}$$

where p_n is the probability of being married.

Equation (4) is estimated using the pooled sample. Results are reported in the first three columns of table 5. Regardless of the controls used, women are more frequently involved in a union in areas where polygyny is more frequent. Moreover the effect of polygyny is very significant.

Polygyny may also affect the share of women remaining single after the end of a union (p_f in Equation 5) due to the death of their husband, a divorce or a separation. We also use a probit model to estimate this effect.

$$p_f = \Phi\left(X^i \beta_f + \pi^i \zeta_f + Y^k \theta_f\right) \tag{5}$$

Results are reported in the last three columns of Table 5.

[Insert Table 5]

We note that the practice of polygyny significantly decreases the probability of a woman remaining single after a divorce, a separation or the loss of her husband. Women remarry more frequently in more polygynous regions, consistent with our theory.

4 Simulated impact of polygyny in sub-Saharan Africa

In this section, we simulate the impact of polygyny on fertility for all sub-Saharan African countries for which data are available. We have seen that: (i) being involved in a polygynous relationship reduces fertility (internal effect); but the societal practice of polygyny (ii) increases the fertility of married women (external effect) either by increasing the nuptiality rate or by reducing the share of women who remain single after a separation, divorce or widowhood.

To calculate the net effect of polygyny, let us consider the women with the vector of characteristics X, whose marital status s is: "never married" (n), "currently married or in a relationship" (m), or "single but formerly married" (f). Let ν_X^s be the fertility rate of the woman with characteristics X and marital status s. Denote by p_X^s, the probability that the marital status of such a woman is s. The average fertility rate of a woman with characteristics X, ν_X is therefore:

$$\nu_X = \nu_X^n p_X^n + \nu_X^f p_X^f (1 - p_X^n) + \nu_X^m \left(1 - p_X^f\right)(1 - p_X^n) \tag{6}$$

Let us denote by π the regional share of women married to polygynous men. Polygyny does not influence the fertility rate of unmarried women directly. That is $\frac{d\nu_X^n}{d\pi} = 0$. The marginal effect of the incidence of polygyny on fertility is therefore:

$$\frac{d\nu_X}{d\pi} = \nu_X^n p_X^n + (1 - p_X^n)\left(p_X^f \frac{d\nu_X^f}{d\pi} + \left(1 - p_X^f\right)\frac{d\nu_X^m}{d\pi}\right) + \frac{dp_X^n}{d\pi}\left(\nu_X^n - \nu_X^m - p_X^f\left(\nu_X^f - \nu_X^m\right)\right)$$

$$+ \frac{dp_X^f}{d\pi}\left(\nu_X^f - \nu_X^m\right)(1 - p_X^n) \tag{7}$$

The first term measures the direct effect of polygyny on fertility. The second term represents the effect of polygyny on fertility via the increase in the nuptiality rate, whereas the third term stands for the effect of polygyny on the probability of remarriage. From this equation, one can derive the simulation formula (see Cahu *et al* (2012) for the determination):

$$E\left[\frac{d\nu}{d\pi}\right] \approx (1 - p^n)\frac{d\nu^m}{d\pi} - \frac{dp^n}{d\pi}\left(E_X[\nu^m] - E_X[\nu^n] - p_f\left(E_X[\nu^m] - E_X[\nu^f]\right)\right)$$

$$- \frac{dp^f}{d\pi}(1 - p^n)\left(E_X[\nu^m] - E_X[\nu^f]\right) \tag{8}$$

We use estimates obtained with country fixed effects (columns 3 and 6 of Table 5) to gauge the theoretical impact of a sudden disappearance of polygyny in all countries of sub-Saharan Africa for which at least one DHS survey is available. For countries which do not have at least three waves of the DHS surveys, the marginal effects of polygyny on nuptiality and fertility cannot be estimated with precision. We infer the results for these countries using the parameter estimates obtained for the twelve countries we have analyzed.

We therefore compute the projection using the parameters estimated using the set of twelve countries described in Table 1. Using regressions at the individual level, one can quantify the different channels through which polygyny affects fertility. According to our results presented in Table 6, in the absence of polygyny, women in Benin would have had about 0.3 fewer children on average. On average, the external impact of polygyny on women's fertility explains 70 percent of this effect, while the impact of polygyny on nuptiality explains the remaining 30 percent. Polygyny therefore seems to have a substantial contribution to demographic growth in sub-Saharan Africa, and can be seen as a partial explanation for the delayed demographic transition.

The estimated impacts of polygyny on fertility at the country level are reported on a map of Africa (see Figure 5). The effects of polygyny appear to be the largest in the Sahel region, and to a lesser extent around the Gulf of Guinea and the Central Eastern part of the continent (Uganda and Tanzania).

5 Concluding remarks

In this paper, we brought forward two findings. Our first result is that women in polygynous unions tend to have a lower fertility rate than women in monogamous unions. The second finding is that fertility is contagious, as higher polygyny prevalence (a predictor of regional-level or neighbors' fertility) has a contagious effect on individual-level fertility of all women, including those married to monogamous men. Women living in regions with high polygyny prevalence produce more offspring than those living in low-prevalence regions. The societal practice of polygyny also positively affects the probability of marriage and remarriage.

We have also simulated the impact of polygyny on fertility for 32 sub-Saharan African countries, showing that a sudden disappearance of polygyny can substantially reduce fertility. These findings altogether clearly suggest that polygyny has contributed to delaying the demographic transition in sub-Saharan Africa. With the recent fall in the incidence of polygyny in most countries, the demographic transition is likely to accelerate.

[Insert Table 6]

[Insert Figure 5]

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Appendix

A. DHS surveys used for computing the external effect of polygyny on fertility

Benin (1996, 2001, 2006), Burkina-Faso (1993, 2003), Burundi (, 2010), Cameroon (1991, 1998, 2004), Central Afr. Rep. (1994), Chad (1996, 2004), Congo, dem. Rep. (, 2007), Congo, Rep. (, 2005), Cote d'Ivoire (1994, 1998, 2005), Ethiopia (1992, 1997, 2003), Gabon (, 2000), Ghana (1993, 1998, 2003, 2008), Guinea (, 1999, 2005), Kenya (1993, 1998, 2003, 2008, 2009), Liberia (, 2006), Madgascar(1992, 1997, 2003), Malawi (1992, 2000, 2004, 2008), Mali (1995, 2001, 2006), Mozambique (1997, 2003), Namibia (1992, 2000, 2006), Niger (1992, 2006), Nigeria (1990, 1999, 2003, 2008), Rwanda (1992, 2000, 2005), Senegal (1992, 1997, 2005), Sierra Leone (, 2008), South Africa (1998), Swaziland (, 2006), Tanzania (1991, 1996, 1999, 2003, 2004, 2005, 2007), Togo (1998), Uganda (1995, 2000, 2006), Zambia (1992, 1996, 2001, 2002, 2007), Zimbabwe (1994, 1999, 2005)

Tables

Table 1: Average statistics for different variables and countries

Country	Polygyny[a]	Fertility[b]	Mortality[c]	Involved[d]	Formerly[e]	Marital age[f]	# obs.[g]
Madagascar	0.03	2.79	42	0.67	0.13	18.5	38,644
Rwanda	0.11	2.71	53	0.	0.16	20	28,293
Zimbabwe	0.15	2.42	32.8	0.61	0.13	18.7	20,942
Malawi	0.17	3.23	73.8	0.73	0.12	17.4	41,465
Ghana	0.24	2.82	38.6	0.7	0.08	18.8	20,012
Tanzania	0.26	4.01	69.3	0.83	0.1	17.6	60,556
Uganda	0.29	3.49	59.7	0.69	0.13	17.4	22,847
Cameroon	0.29	3.08	48.2	0.74	0.08	17.5	20,028
Côte d'Ivoire	0.33	3.31	47.5	0.71	0.07	17.8	20,825
Nigeria	0.33	3.24	60.5	0.74	0.05	17.2	33,831
Senegal	0.42	3.59	47.5	0.8	0.05	17.1	29,505
Benin	0.46	3.18	49.8	0.74	0.05	18.2	29,504

[a] Share of women whose husband has more than one spouse.
[b] Average total number of children ever born per woman.
[c] Number of children below one who died per 1,000 births.
[d] Share of women either married or in a relationship.
[e] Share of women either divorced, separated or in widowhood.
[f] Average age at first marriage.
[g] Sample size of women.
Source: The Demographic and Health Surveys, ICF International company.
All statistics are computed for women between 15 and 49.

Table 2: Effect of polygyny on fertility at the individual level

Country	Benin	Côte d'Ivoire	Cameroon	Ghana	Madagascar	Malawi
Polygyny	-0.09	0.15	-0.18	-0.12	-0.09	-0.14
	(4.2)**	(3.8)**	(4.5)**	(3.6)**	(3.3)*	(4.9)**
Marriage length	0.9	0.78	0.82	0.76	0.79	0.83
	(57.1)**	(41.1)**	(33.1)**	(41.8)**	(51.7)**	(46.9)**
Mortality	28.7	4.66	7.5	13.61	12.5	5.41
(regional)	(25.7)**	(3.7)**	(5.2)**	(11.2)**	(22.4)**	(7.1)**
Mortality	5.5	4.24	-0.81	7.54	-0.58	12.08
(individual)	(17.8)**	(8.8)**	(1.9)	(15.2)**	(2.8)*	(42.8)**
# obs.	21590	12046	12962	12718	26065	21282
adj. R^2	0.67	0.55	0.53	0.62	0.66	0.57
Country	Nigeria	Rwanda	Senegal	Tanzania	Uganda	Zimbabwe
Polygyny	-0.22	-0.08	-0.21	-0.19	0.06	-0.36
	(4.4)**	(2.5)+	(5.4)**	(5.7)**	(1.6)	(5.1)**
Marriage length	1.25	0.92	0.81	0.89	0.74	0.99
	(52.1)**	(42.6)**	(39.4)**	(42.2)**	(40.1)**	(59.2)**
Mortality	2.97	16.39	3.7	6.16	7.12	17.8
(regional)	(3.4)*	(16.6)**	(3.9)**	(4.7)**	(5.8)**	(15.9)**
Mortality	5.9	0.68	0.79	0.64	11.21	-1.71
(individual)	(15.5)**	(1.5)	(2.4)+	(1.6)	(17.3)**	(4.3)**
# obs.	9070	14,441	13,738	14,865	12,402	24,282
adj. R^2	0.72	0.63	0.63	0.65	0.66	0.53

Dependent variable is the total number of children ever born. OLS regressions.

T-stats are between brackets. +, *, ** indicate significance at the 5 percent, 1 percent and 0.1 percent level.

Additional controls: Age, age^2, years of schooling, Rural, year trend, number of unions, "declared non fecund", religion and region binary variables.

Sources: Authors' computations from DHS.

Table 3: Descriptive statistics of social/cultural characteristics at the local level

Variable	# Obs.	Mean	Std. Dev.	Min	Max
π^k	547	0.25	0.14	0.00	0.63
h^k	559	4.69	2.15	0.26	10.24
$R(catholic)^k$	504	0.25	0.19	0.00	0.85
$R(protestant)^k$	504	0.21	0.19	0.00	0.93
$R(muslim)^k$	504	0.29	0.33	0.00	1.00

Sources: Authors' computations from DHS.

Table 4: Contagious effect of fertility: The effect of regional-level polygyny on individual-level fertility

Dep. var.	------------------------ total number of children ever born (OLS) ------------------------							
Polygyny (regional)	1.03 (21.8)**	0.81 (18.5)**	1.09 (24.1)**	0.59 (7.4)**	0.89 (17.5)**	0.71 (15.0)**	1.01 (20.7)**	0.58 (6.4)**
Schooling (regional)	0.05 (14.7)**	0.02 (6.0)**	0.01 (2.4)+	0.02 (4.0)**	0.05 (13.3)**	0.02 (4.7)**	0.01 (2.3)+	0.01 (2.8)*
Mortality (regional)	10.81 (44.6)**	5.69 (24.9)**	5.22 (22.8)**	6.31 (23.7)**	10.58 (39.2)**	5.4 (21.4)**	5.01 (19.9)**	5.59 (19.0)**
Mortality (individual)	4.48 (34.0)**	3.64 (29.7)**	3.58 (29.2)**	3.55 (28.7)**	4.13 (26.4)**	3.34 (23.1)**	3.29 (22.8)**	3.2 (22.0)**
Marriage length	-	yes	yes	yes	-	yes	yes	yes
Religion	-	-	yes	yes	-	-	yes	yes
Country	-	-	-	yes	-	-	-	yes
# obs.	126167	126167	126167	126167	93946	93946	93946	93946
adj. R^2	0.57	0.63	0.63	0.64	0.59	0.65	0.65	0.65
Sample	All women in a relationship				Unique spouse only			

Additional controls: Age, age^2, years of schooling, Rural, year trend, Body Mass Index, "declared unfecond" dummy, religion dummies.

Sources: Authors' computations from DHS.

Table 5: Probit estimates of the effects of polygyny on marriage and remarriage

Dep. Var.	Prob. of not being single			Prob. of being divorced/widow		
Polygyny (regional)	0.73 (23.6)**	0.8 (24.6)**	1.01 (16.6)**	-1.45 (36.5)**	-1.44 (35.1)**	-0.9 (12.8)**
Schooling (regional)	-0.02 (8.1)**	-0.03 (11.3)**	-0.04 (13.0)**	0.00 (0.4)	0.00 (0.6)	0.00 (1.0)
Religion (regional)	-	yes	yes	-	yes	yes
Country	-	-	yes	-	-	yes
# obs.	179420	179420	179420	144720	144720	144720
pseudo R^2	0.22	0.24	0.24	0.05	0.05	0.06
Sample	All women			Excluding never married women		

Probit regressions. Additional controls: Age, age^2, years of schooling, Rural, year trend, and dummies for low and high Body Mass Index, "declared unfecond" and religions.

Sources: Authors' computations from DHS.

Table 6: Simulated impact of Polygyny on total fertility by country and channel

Regressions	---------------------------Individual---------------------------				
Channel	Internal	External	Marriage	Remarriage	Total
Guinea	0.03	-0.28	-0.11	-0.03	-0.39
Togo	0.04	-0.26	-0.13	-0.04	-0.38
Burkina-Faso	0.04	-0.25	-0.13	-0.02	-0.36
Chad	0.05	-0.22	-0.1	-0.06	-0.34
Cote d'Ivoire*	-0.05	-0.15	-0.08	-0.02	-0.3
Benin*	0.04	-0.21	-0.11	-0.03	-0.3
Nigeria	0.03	-0.18	-0.11	-0.04	-0.3
Senegal*	0.09	-0.21	-0.14	-0.03	-0.29
Mali	0.03	-0.2	-0.09	-0.02	-0.29
Uganda*	0	-0.14	-0.08	-0.03	-0.24
Nigeria*	0.07	-0.15	-0.12	-0.02	-0.22
Tanzania*	0.05	-0.15	-0.06	-0.03	-0.18
Central Afr. Rep.	0.04	-0.15	-0.05	-0.02	-0.18
Sierra Leone	0.03	-0.15	-0.04	-0.01	-0.18
Cameroon*	0.05	-0.14	-0.06	-0.02	-0.17
Congo Dem. Rep.	0.02	-0.09	-0.07	-0.02	-0.16
Mozambique	0.03	-0.13	-0.04	-0.02	-0.16
Ghana*	0.03	-0.1	-0.06	-0.02	-0.15
Liberia	-0.04	-0.07	-0.02	-0.01	-0.13
Swaziland	0.02	-0.06	-0.05	-0.02	-0.12
Zambia	0.02	-0.07	-0.04	-0.02	-0.11
Malawi*	0.02	-0.09	-0.04	-0.01	-0.11
Gabon	0.02	-0.1	-0.02	0.00	-0.11
Kenya	0.02	-0.07	-0.04	-0.01	-0.1
Ethopia	0.01	-0.05	-0.04	-0.02	-0.09
Rwanda*	0.01	-0.04	-0.03	-0.01	-0.08
Congo Republic	0.01	-0.06	-0.02	-0.01	-0.08
Namibia	-0.02	-0.03	-0.01	0.00	-0.06
Zimbabwe*	0.05	-0.06	-0.02	-0.01	-0.04
Burundi	0.01	-0.02	-0.02	0.00	-0.03
Madagascar*	0.00	-0.02	-0.01	0.00	-0.02
South Africa	0.00	-0.02	-0.01	0.00	-0.02

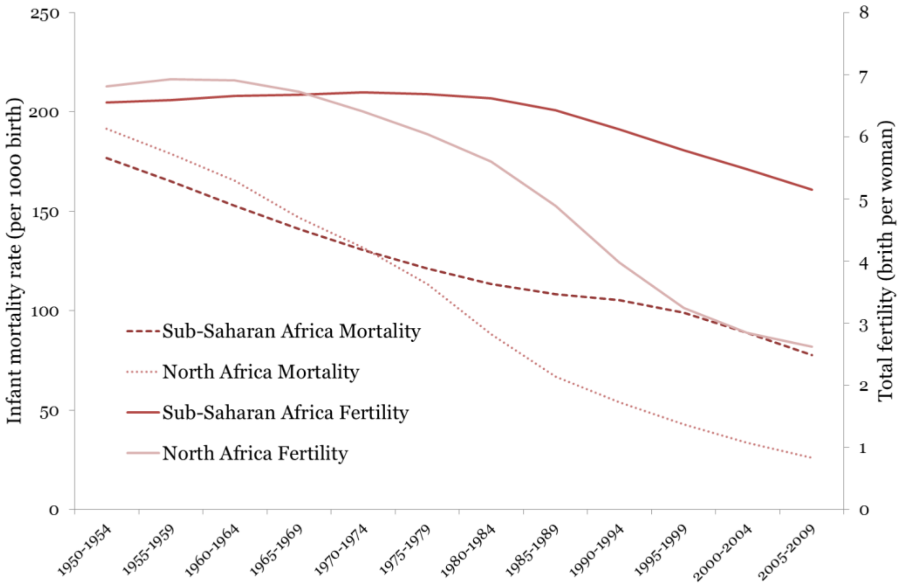
Fertility is the average number of children ever born per women.

Data from countries followed by "*" were used to estimate the marginal effects of polygyny on fertility and nuptials.

Sources: Authors' computations from DHS.

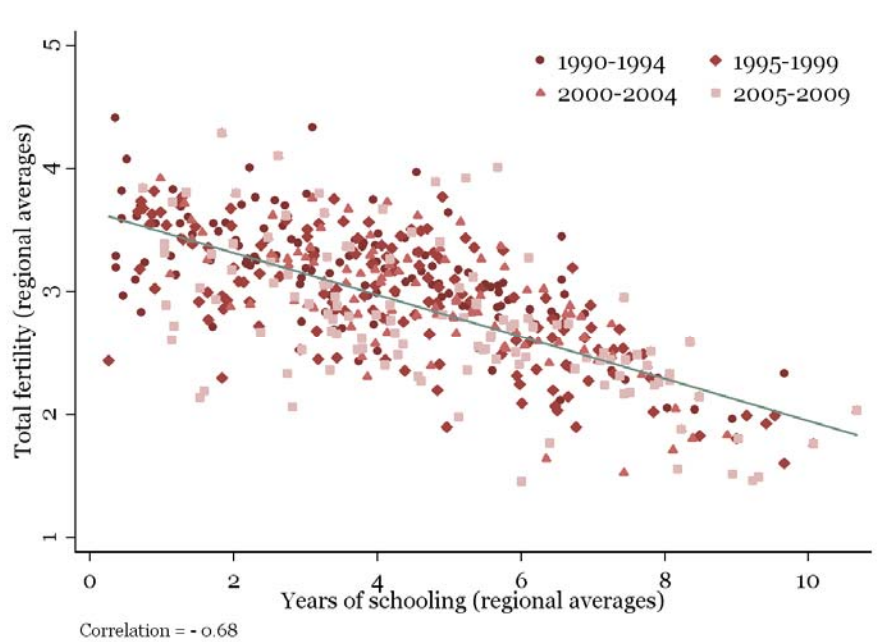
Figures

Figure 1: The demographic transition in Northern and sub-Saharan Africa



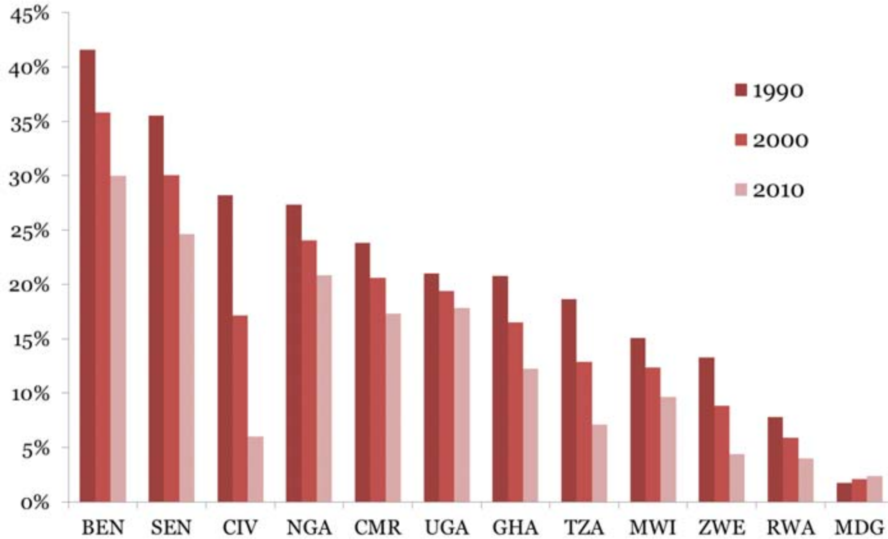
Sources: Authors'computation from World Bank Indicators

Figure 2: Correlation between fertility rates and education of women (15-49) at the regional level.



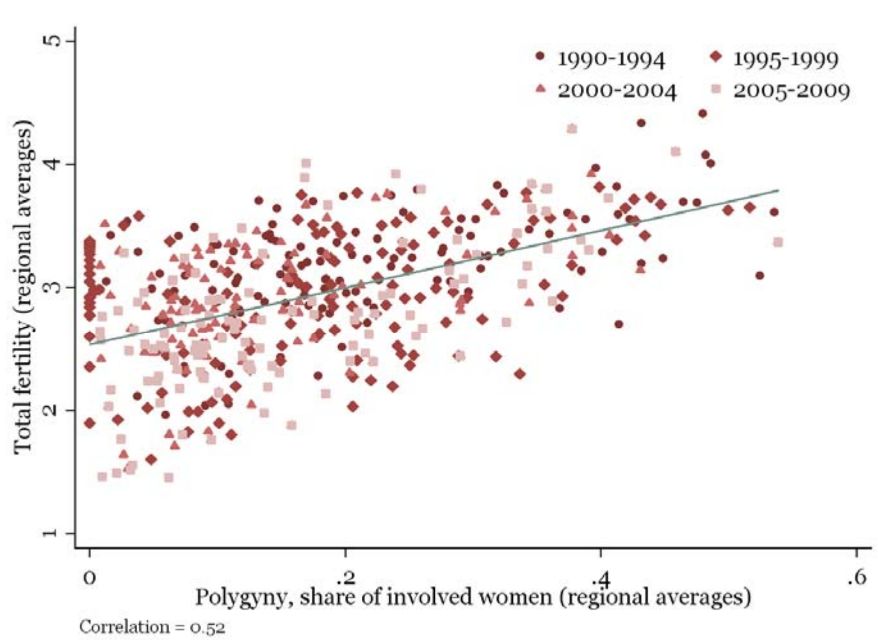
Source: Authors' calculations from DHS in a selection of countries (See table 1 for details on how polygyny and fertility were computed)

Figure 3: Evolution of the incidence of polygyny in a selection of Sub-Saharan African countries.



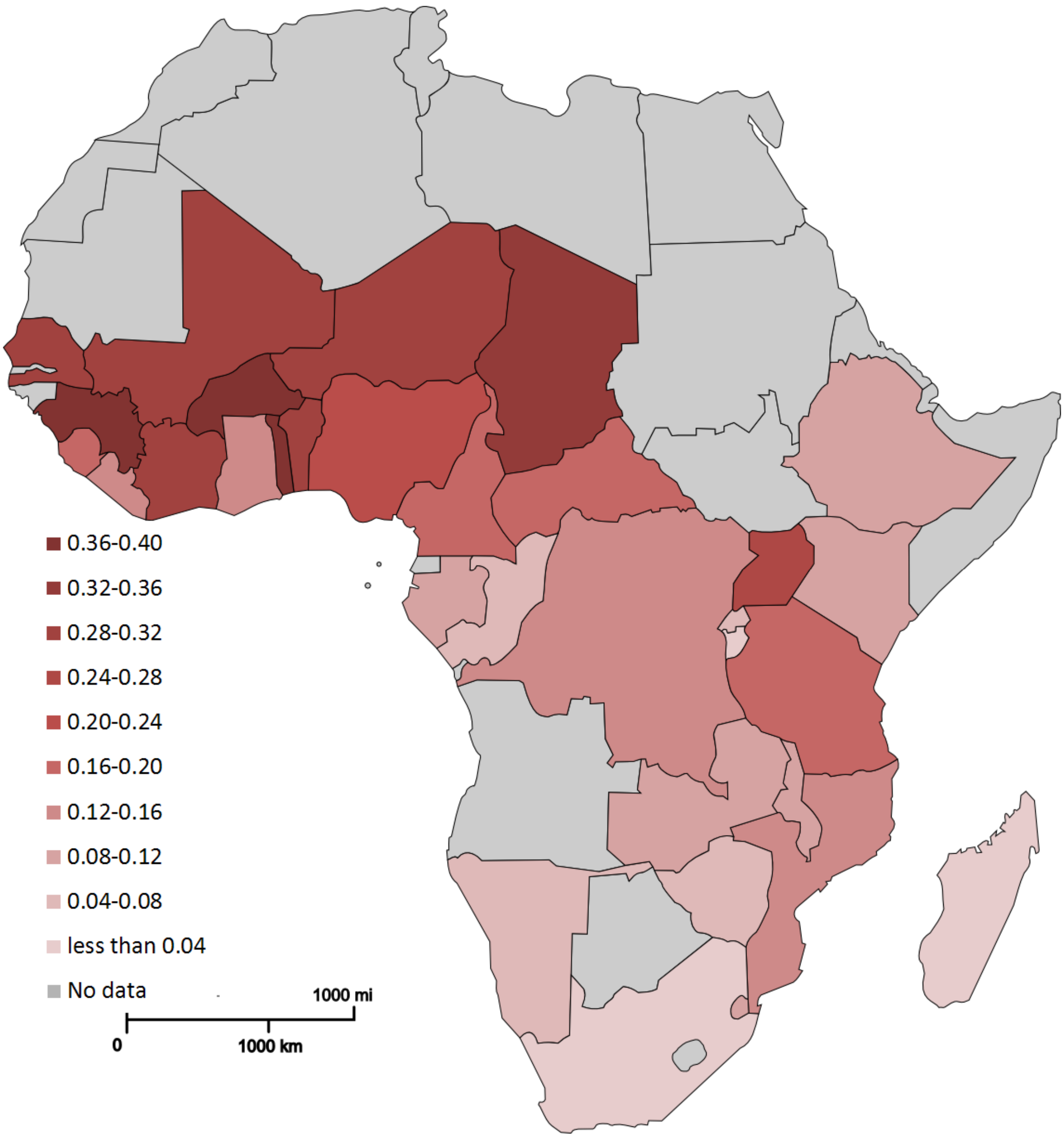
Sources: Authors'compuations from DHS.

Figure 4: Correlation between fertility rates and prevalence of polygyny at the regional level.



Source: Authors' calculations from DHS in a selection of countries (See table 1 for details on how polygyny and fertility were computed)

Figure 5: Impact of polygyny incidence on the total number of children ever born by woman according to estimations at the individual level.



Sources: Authors' computations from DHS.