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"Polygyny and the Economic Determinants of Family Formation Outcomes in Sub-Saharan Africa"

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Polygyny and the Economic Determinants of Family Formation Outcomes in Sub-Saharan Africa*

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Abstract

This paper studies how short-term changes in aggregate economic conditions influence family formation outcomes in the presence of polygyny. It develops a simple marriage market framework with overlapping generations in which polygyny is modeled as a sequential one-to-one matching, and bride price acts as an important source of consumption smoothing. When there is a drought, the demand for second spouses (from older men) is more sensitive to the income and bride price drop than the demand for first/unique spouses (from younger men). This leads to an increase in the market share of younger men and a much smaller rise in the equilibrium quantity of female child marriage compared to the one observed in monogamous markets. The attenuation effect is such that droughts have no detectable impact on the timing of marriage and fertility onset in high polygyny areas. Evidence from global crop price shocks confirms these patterns. It shows that higher food prices affect marital outcomes in opposite directions in crop-producing and crop-consuming areas.

JEL Codes: J1, O15

Keywords: Marriage market, local norms, polygyny, bride price, income shocks, informal insurance.

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1 Introduction

Local norms and culture are crucial for economic development, and the efficacy of policy interventions may depend on the context in which they are enacted (Ashraf et al., 2020; Collier, 2017; World Bank, 2015). The marriage market is an important determinant of household welfare that relies heavily on such norms. One of the most salient norms of this market in Sub-Saharan Africa is the extent to which polygyny is practiced.[1] There is indeed a substantial spatial variation in its presence and intensity with some persistence over time (Fenske, 2015; Tertilt, 2005; Jacoby, 1995). Figure 1 shows the share of women in union with a polygamous husband (split in terciles) for each 0.5 × 0.5 decimal degree grid cell. Monogamy is the norm in the green cells (lowest tercile), with more than 50% of these cells having a polygyny rate below 5%. On the other side of the spectrum, polygyny rates are higher than 40% in high polygyny areas (red cells for the top tercile). This variation is relatively persistent over time, with only a slow decline observed in high and medium polygyny areas.[2] It creates strong local norms that deeply affect the structure of marriage markets and the characteristics of unions that are formed in them.

Family formation outcomes play a crucial role in household welfare after a union. In both monogamous and polygamous markets, the timing of marriage is an important outcome that affects the well-being of women and their offspring. Child marriage is still a common practice across Sub-Saharan Africa, with an average prevalence of 56% (UNICEF, 2019). Differences in age of marriage are associated with different health, fertility, and socio-economic outcomes for mothers and children (Corno et al., 2020; Duflo et al., 2015; Save the Children, 2004). The presence of polygyny gives rise to other relevant marital outcomes that have significant consequences for female welfare. First, there is spousal ranking. Marrying as a first or unique spouse (versus getting matched as a second or higher order spouse) leads, on average, to better bargaining power, higher access to household resources, and better outcomes for one's children (Munro et al., 2019; Matz, 2016; Reynoso, 2019). Second, there is the spousal age gap. Marrying older men is often associated with having less bargaining power in the union and a higher likelihood of early widowhood (Carmichael, 2011; Atkinson and Glass, 1985; Van de Putte et al., 2009). Understanding the short and long-run drivers of these key family formation outcomes is therefore crucial for economic policy design and implementation in developing countries.

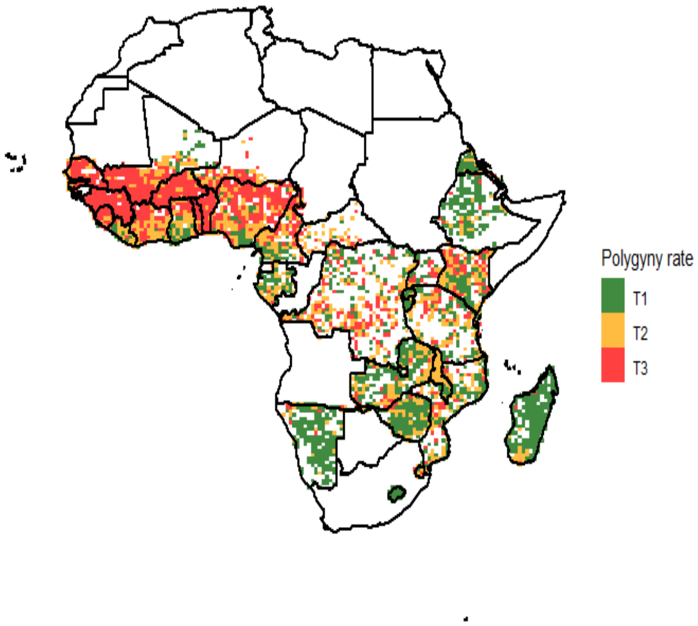
This paper studies how short-term variations in aggregate economic conditions affect family formation outcomes in the presence of polygyny. In Sub-Saharan Africa, it is customary for the groom or his family to pay a bride price (substantial monetary or in-kind transfer) to the bride's family at the time of marriage. These bride price payments are persistent traditions that act as an important source of consumption smoothing and play a crucial role when households make marital/investment decisions (Corno et al.,

[1] Polygamy is a type of union that includes more than two partners. Polygyny is the most common form of polygamy in which men can be married to several wives at the same time.

[2] The spatial variation in polygyny rates is driven by a combination of historic and slow-moving socio-economic factors such as pre-colonial ethnic customs, male inequality (hierarchy in traditional societies), colonial schools, religion, female productivity in agriculture, etc... (Fenske, 2015; Boserup, 1970; Becker, 1974; Jacoby, 1995; Gould et al., 2008; De La Croix and Mariani, 2015). These determinants explain its persistence over time.

2020; Ashraf et al., 2020). Aggregate economic shocks are also common in these agrarian economies. They affect agents on both the supply and the demand side of the marriage market. This creates some ambiguity/complexity in how such shocks may impact family formation outcomes when polygyny is allowed.

Figure 1: Practice of Polygyny across Space in Sub-Saharan Africa



Note: Polygyny rate is the average share of women (aged 25 and older) that are in union with a polygamous male in each 0.5 × 0.5 decimal degree (∼ 50×50 km) weather grid cell. It is computed from Demographic and Health Survey (DHS) data collected between 1994 and 2013. The continuous rate is split in terciles. T1 represents grid cells with low polygyny (less than 16%), T2 is for areas with medium polygyny (between 16 and 40%), and T3 is for areas with high polygyny (more than 40%).

I overcome this complexity by modeling the key features that characterize marriage markets in Sub-Saharan Africa. For that, I consider an overlapping generation matching model in which each birth cohort is active on the market for at most two periods. On the supply side, girls leave the market once they marry. Child marriage corresponds to girls getting married during their first period of being active on the market (between ages 12 and 17, for instance). On the demand side, men also leave the market once they get married when polygyny is not allowed. When it is permitted, a certain share of men remains active on the market after being matched during their first participation. Those among them who find it optimal to second-marry will have two spouses when they exit the marriage market.[3] Polygyny is therefore modeled as a sequential one-to-one matching.

At any given period, two generations of men and women are on the market, which may lead to multiple equilibria in the matching pattern. The most straightforward equilibrium consistent with the data is such that there is an excess quantity of unmarried older men on the market (2nd participation) compared

[3]Bigamy is by far the most common form of polygyny in Sub-Saharan Africa as shown in Figure A10.

to unmarried older women. This leads to a substantial number of cross-cohort unions.[4] The market is cleared by the youngest generations because they have the outside option of waiting one extra period before they agree to a union. In this setting, the aggregate demand for child brides can be decomposed into two independent components: the demand for first/unique spouses from young adult men and the demand for second spouses from older men. In monogamous marriage markets, only the former exists.

When aggregate income is low, many households want to bring forward their daughters' marriage so that they can smooth consumption with the bride price payment. This leads to an increase in the supply of child brides. Households on the demand side of the market are also affected by the same negative shock, so the equilibrium bride price will fall. The relative sensitivity of the demand for first/unique spouses to the income and price drop compared to the demand for second spouses will determine which component will see an increase in their market share when aggregate income is low. I show that in settings where polygyny is common, even among relatively poor people (not just the rich elite), the demand for second spouses is more elastic to income and price changes than the demand for first/unique spouses. This means that adverse economic shocks will decrease the market share of older men (looking for a second spouse) to the benefit of younger men (looking for a first/unique spouse).

The second prediction of the model is on how aggregate shocks affect girls' marriage timing. The equilibrium quantity of child marriage will vary depending on which side of the market is more sensitive to the income and price decline. In the case of monogamous marriage markets, Corno et al. (2020) have shown that negative shocks increase child marriage because the supply of child brides is more sensitive than the demand for unique spouses.[5] When polygyny is allowed, the demand for second spouses is more elastic to the income and price drop compared to the demand for first/unique spouses. This means that the overall demand will be more sensitive than when we are in a monogamous market leading to a much smaller rise in the equilibrium quantity of child marriage. The magnitude of this attenuation effect depends on the strength of the polygyny norm. Areas with the strongest polygyny norms will have an even smaller rise (if any) in the equilibrium quantity of child marriage when there is a negative shock.

To test the model's implications, I examine the effect of rainfall and global food price shocks on the key family formation outcomes in Sub-Saharan Africa: (i) the timing of unions for girls, (ii) their likelihood of marrying as first/unique spouses (spousal ranking), and (iii) their likelihood of marrying husbands that have a low age gap. Rainfall shocks are a major and plausibly exogenous source of income variability in areas that rely on rain-fed agriculture. Low levels of rainfall reduce annual crop yields by 10 % on average, but there is no clear positive relationship between higher rainfall realization and crop yields in Sub-Saharan Africa (Corno et al., 2020; Burke et al., 2015). To test whether households and markets react in a symmetric way to positive and negative shocks, I also use income variation induced by plausibly

[4] Data shows that the age of marriage for women that are unique, first, or second spouses are very similar within each country (see Appendix Figure A11). There is also a large age gap between husband and first/unique spouse (8 years on average). Moreover, men marry a second spouse on average 10 years after marrying their first spouse (see Appendix Figure A12).

[5] For the case of monogamy, the difference in income and price elasticity of supply and demand comes from the economic support that sons provide to their parents even after getting married in patrilocal societies.

exogenous changes in world agricultural commodity prices.[6] These can generate opposite effects for areas that produce crops and those that consume them. A rise in crop price such as the one observed during the last agricultural commodity super cycle (which peaked with the global food price crisis of 2007/2008 and 2010/2011) leads to an increase in real income in crop-producing areas and a decrease in net-consuming areas (Verpoorten et al., 2013). This has also been shown to fuel violence in Africa (McGuirk and Burke, 2020). The variation in aggregate income that comes from global food price shocks is also of a different nature compared to rainfall shocks and serves as an interesting robustness check for the predictions of the model. The former is a real income shock (for a given production level), while the latter is a production shock.

I use Demographic and Health Survey (DHS) data for more than 300,000 women spread across Sub-Saharan Africa and rainfall data from the University of Delaware Air Temperature and Precipitation project to evaluate the impact of droughts on marital outcomes in the presence of polygyny. As predicted by the model, the empirical evidence shows that droughts increase the market shares of young men that are looking for a first/unique spouse at the expense of older men. Exposure to a drought during the prime marriageable age (between ages 12 and 17, for instance) significantly reduces the spousal age gap only in high polygyny areas and by 1.2 years (10 % of the average age gap).[7] It also decreases the likelihood of marrying as a second/ higher order spouse by 2.4 percentage points (14 % of the average share of second/higher order spouses). This evidence confirms that the demand for second spouses is more sensitive to the income and price drop from droughts than the demand for first/unique spouses.

The empirical evidence also shows that droughts have a much bigger impact on the hazard of child marriage (between ages 12 and 17) and early marriage (between 12 and 24) in areas with less polygamy. In monogamous markets, a drought raises the average annual hazard of child marriage by 5%.[8] This effect decreases progressively as we move to areas with higher polygyny rates until it vanishes completely. In areas with the strongest polygyny norms, droughts have no detectable impact on the timing of marriage.

For the second source of variation in aggregate income, I follow McGuirk and Burke (2020) and define a producer price index (PPI) by combining high-resolution time-invariant spatial data on where specific crops are grown with annual international price data for each crop to form a cell-year measure. Similarly, a country-year level consumer price index (CPI) is obtained by combining cross-sectional data on food consumption from the United Nations Food and Agriculture Organization (UN FAO) with temporal variation in world prices. I find that a standard deviation rise in PPI decreases the hazard of early marriage by 0.6 percentage points (4% of the annual average hazard) for women living in rural areas in

[6]Households may move forward the timing of marriage of their daughters when facing a negative shock but fail to delay it when there is a positive shock. This behavior is consistent with mental accounting life cycle models in which households treat different components of wealth as non-fungible (Shefrin and Thaler, 1988; Thaler, 1999). There is evidence of asymmetric consumption smoothing in reaction to income shocks even for households that are not budget-constrained (Baugh et al., 2021; Christelis et al., 2019; Jappelli and Pistaferri, 2010).

[7]Droughts do not affect the spousal age gap in low polygyny areas.

[8]This represents almost the double of the average effect documented in Corno et al. (2020). Their estimates show the average impact of droughts across the whole region (not just in monogamous areas), so they do not take into account the fact that polygamous markets may react differently to droughts.

low polygyny cell grids. This effect is halved in medium polygyny areas and vanishes in high polygyny areas. In these areas, the rise in PPI increases the market shares of older men looking for a second spouse at the expense of younger ones. The rise in CPI has opposite effects on women living in urban areas: A standard deviation rise in CPI increases the hazard of early marriage by 1.5 percentage points in low and medium polygyny areas but has no significant effect in high polygyny areas.

These differences in the equilibrium response of marriage outcomes to short-term shocks translate into differences in fertility onset and levels by age 25.[9] Sensitivity and robustness checks show that the documented patterns are present only among women from ethnic groups that practice bride price payments (as predicted by the model). Importantly, they are not driven by other cultural factors that are correlated with polygyny, such as religion or matrilineal/patrilineal kinship systems. They are also not driven by differences in the reaction of the supply side of the market to the shocks, differential migration, differential sizes of the relevant marriage markets, or differential effects of the shocks on household income.

The findings in this paper have two main policy implications. First, they suggest that policies that generate windfall aggregate income (such as large-scale cash transfer programs) can reduce child marriage in monogamous areas, but they will have unintended negative consequences for marital outcomes in polygamous areas.[10] In equilibrium, the extra income will fund more second unions for older men with limited resources. These types of policies should therefore be accompanied by support measures in polygamous areas to ensure they do not deteriorate marital outcomes. Second, aggregate income stabilization policies are more efficient/needed in monogamous areas since they can help against an increase in child marriage that will otherwise occur in these places. In polygamous markets, however, negative shocks can create opportunities for young men because they are more likely to find a spouse and for women because they are more likely to marry younger men as first spouses (which improves their bargaining power within the household). Aggregate income stabilization policies will act as a push against this compositional change without improving the equilibrium quantity of child marriage. In the presence of polygyny, it is, therefore, crucial to target interventions that aim to improve marital outcomes to only one side of the market.

Related Literature

This paper is related to three main strands of economic literature. First, it contributes to a recent and growing literature on the effect of income shocks on marital decisions/outcomes in developing countries (Corno and Voena, 2021; Corno et al., 2020; Hoogeveen et al., 2011; Chort et al., 2021). These papers assume that markets only allow monogamous unions, and they, therefore, focus on the impact of aggregate income shocks on marriage timing. Corno et al. (2020) use a supply and demand model with a one-to-one matching framework to show that the effect of droughts on girls' marriage timing depends on the direction

[9]Negative shocks increase the likelihood of early fertility onset in low polygyny areas but have no detectable effect in high polygyny areas (the opposite for positive shocks).

[10]The evidence on how markets react to positive shocks allows me to infer the potential effect of policy interventions that generate windfall aggregate income. The evidence from adverse shocks such as droughts could not sustain by itself such a policy conclusion, given the possibility of asymmetric reactions.

of marriage payments: It increases child marriage in the presence of bride price (paid by groom's family) and decreases it in the presence of dowry (paid by bride's family). The other papers also focus on rainfall shocks as a source of variation in aggregate economic conditions. Rexer (2022) shows that young women delay marriage in response to good pre-marital rainfall, which increases marriage inequality and violence primarily in polygamous areas. The paper explores the potential mechanism behind this effect by treating rainfall variations as supply-side pre-marital shocks (mean rainfall deviation in the four years prior to a given age) and argues that they increase the cumulative hazard of marriage (up until age 25) only in polygamous areas. My paper focuses on how rainfall shocks during the prime marital years affect the timing of unions (and other marital outcomes). Rainfall variation is therefore treated as an aggregate yearly shock in order to link it directly to the exact timing of marriage (as in Corno et al. (2020)). My results show that, on the contrary, rainfall shocks have a stronger effect on the timing of marriage in monogamous areas.[11] The supply side mechanism suggested in Rexer (2022) plays a minor role in how the marriage market clears from one year to another with changing economic conditions.

My paper adds to this literature in several respects. First, it extends the one-to-one matching framework to analyze how aggregate economic conditions affect marital outcomes when polygyny is allowed. The presence of polygyny gives rise to two other key family formation outcomes besides the timing of marriage that are also affected by aggregate economic conditions: wife ranking and husband-wife age gap. These three marital outcomes interact with each other and with short-term economic shocks in non-trivial ways that are explicitly modeled and empirically documented for the first time in this paper. Second, I also use an additional source of variation in aggregate income that has not been used so far in this literature: changes in real income due to global commodity price fluctuations. As argued earlier, this generates both positive and negative shocks for food-producing and food-consuming areas and is used to confirm that households and markets react in a symmetric way to aggregate shocks.

Second, this paper contributes to the large literature that investigates the coping mechanisms used by poor households to deal with income shocks (Rosenzweig and Stark, 1989; Townsend, 1994; Fafchamps and Lund, 2003; Kazianga and Udry, 2006; Jayachandran, 2006; Morten, 2019). Receiving a bride price is an important strategy for coping with such shocks, but this paper shows that their aggregate effect depends on local norms regarding the practice of polygyny. In high polygyny areas, adverse shocks do not change the equilibrium levels of child marriage, but they increase the market shares of young men that are looking for a first spouse at the expense of older men that are looking for a second one.[12] This can improve welfare for two reasons. First, as argued earlier, women who marry in these hard times may benefit from marrying as first/unique spouses to younger men. Second, evidence suggests that the

[11]This is also the case when I use only data from Nigeria, the country studied in Rexer (2022) (see Appendix Section A.6 for more details). Importantly, my analysis abstracts from the potentially complex interactions between violence and marital decisions by focusing on the cohorts of girls not exposed to any conflict when making marital decisions (no conflict before age 25).

[12]A major implication of this finding is that households living in high polygyny areas will rely more on other strategies to cope with aggregate shocks, such as liquidating assets/buffer stocks or off-farm employment. Their strategies to cope with income volatility should be more similar to that of households who live in areas with no bride price custom. Female child marriage plays a minor role for that purpose in both cases.

reallocation of wives to younger men can improve welfare because they become more likely to engage in productive activities at their full potential.[13] By showing that even temporary shocks affect spousal ranking, this paper also contributes to a growing literature on the determinants and consequences of wife seniority in polygamous households (Reynoso, 2019; Matz, 2016; Rossi, 2019; André and Dupraz, 2019).

Finally, this paper fits within the body of research on the importance of culture and institutions in shaping economic behavior. Most of this literature has studied the role of cultural values and beliefs, such as marriage payments, polygyny, trust, family ties, and gender norms on economic development (Platteau, 2000; Jacoby, 1995; Tertilt, 2005; La Ferrara and Milazzo, 2017; Jayachandran and Pande, 2017) and on household decision-making (Bishai and Grossbard, 2010; Anderson and Bidner, 2015; Ashraf et al., 2020; Bhalotra et al., 2020; Anukriti et al., 2021). I contribute to this literature by showing that local norms regarding the practice of polygyny significantly influence the equilibrium reaction of the marriage market to aggregate income shocks. Therefore, it is crucial to consider the marriage market structure when designing and implementing policy interventions.

The paper is structured as follows. Section 2 presents the theoretical framework used for the analysis. In Section 3, I discuss the data and some descriptive evidence. Section 4 elaborates on the empirical strategy used to test the model's main predictions. Section 5 shows the main empirical results and some robustness checks. Section 6 concludes.

2 Model

In this section, I propose a simple model to study how marital outcomes react to short-term aggregate economic shocks in the presence of polygyny. It is a simple supply and demand marriage market model that features sequential one-to-one matching and overlapping generations. This model also encompasses what happens in monogamous markets (studied in Corno et al. (2020)) as a special case.

2.1 Set Up

Market Structure: The marriage market at each period t involves men and women of two consecutive birth cohorts, as shown in Table 1. On the demand side, teenage sons (cohort B_1) are too young to participate in the market. Young adult sons (cohort B_2) are the youngest men on the market, and old adult sons are the oldest (cohort B_3). Each birth cohort is active on the market for up to two periods, leaving it for good afterward. They can marry only once per period.

Men who married young at period $t-1$ (denoted by $\mathcal{M}_o^m$) can be looking for a second spouse at

[13] In polygynous societies and those with a strong gender imbalance, unmarried young men often engage in crime and other violent activities, so marrying earlier means reallocating time to more productive activities such as work and raising offspring (Edlund and Lagerlöf, 2012; Edlund et al., 2013; Cameron et al., 2019; Rexer, 2022; Koos and Neupert-Wentz, 2020).

period t.[14] The extent to which this happens in a given market is determined local social norms.[15] These norms are constant over time and vary from market to market for reasons that are exogenous to the model, as argued in Section 3.4. Let $p \in [0, 1]$ denote the share of men who return to the market for second spouses. $p = 0$ means polygyny is not allowed, and the marriage market is exclusively monogamous. $p = 1$ means all the men return to the marriage market looking for a second spouse. Not everyone looking for a second spouse will be able to find/afford one. The equilibrium share of men that marry a second spouse is therefore determined endogenously within the model.

On the supply side of the market, teenage daughters (cohort B_1) are already active and can potentially be married off by their parents as child brides.[16] They are the youngest cohort on the marriage market at period t. Young adult daughters (cohort B_2) are the oldest active cohort. Older daughters (cohort B_3) are no longer active on the market because their fertility prospects are too limited at this age. Women leave the market for good upon marriage, and I assume that there is no divorce or remarriage in this setting for simplicity.[17]

The last row of Table 1 shows whether a child is old enough to emancipate economically from his parents and autonomously run his own production and consumption unit. Until young adulthood, sons are part of their parents' production and consumption unit with a positive net contribution $w_y^m > 0$. The parents decide to support or not the marriage of their son at this stage. The son then splits/emancipates and creates his own production/consumption unit when he becomes an old adult.[18]

Table 1: Marriage Market Structure at t

Birth cohort	B_1	B_2	B_3
Male Side		$\mathcal{U}_y^m$	$\mathcal{U}_o^m + p\mathcal{M}_o^m$
Female Side	$\mathcal{U}_y^f$	$\mathcal{U}_o^f$	
Emancipation	No	No	Yes

Age bride cohorts: Youngest (12-17); Oldest (18-30)
Groom cohorts: Youngest (15/18-25); Oldest (26-35)

[14] All the other active participant on the market are bachelors (unmarried) denoted by $\mathcal{U}$ in Table 1. The subscripts indicate their cohort (young y or old o) and the superscripts their gender (male m or female f).

[15] A social norm is defined here as a shared understanding of what is a desirable/acceptable behavior in a given area.

[16] In the data, 54% of girls are married by age 18 versus less than 1% for men.

[17] Divorce rates are relatively high in Sub-Saharan Africa compared to other developing regions (around 25%). However, most divorces happen within the first years of union (Villar et al., 2018) while men tend to marry a second spouse on average 10 years after their first union. Divorces are mostly driven by factors other than polygyny such as urbanization, education, female employment, and kinship systems. Divorce rates are even higher in monogamous areas compared to polygamous ones.

[18] There is ample evidence that parents are very involved in the first union of their sons (especially the young ones). They provide start-up capital such as land for the new household, arrange and host the marriage ceremony, and often cover most expenses, including bride price payment. Parents can also provide some of this support to old sons that are getting married for the first time. However, the decision to marry a second spouse and the costs involved are paid for by the groom himself with little involvement from his parents (Goldschmidt, 1974; Mondain et al., 2004; Antoine et al., 2002).

After their economic emancipation, old adult sons still contribute to their parents' household consumption because of patrilocality.[19] I assume that this contribution is higher if they got married during young adulthood ($w_o^{m,h} > w_o^{m,l}$). Several factors support this assumption. First, being single can prevent the newly emancipated son from producing resources at his full potential.[20] Second, this could capture some reciprocity of the son towards his parents since they helped him get married early, and he does not have to pay a bride price right away after his emancipation.

Daughters move from their parents' consumption/production unit to that of their husband's family when they get married (patrilocality). They are no longer active on the marriage market by the time they could emancipate from their parents, so they would have to remain single forever in this case. The net contribution of a daughter to her parent's (or her husband's) production/consumption unit is w_y^f when she is among the youngest cohort on the market and w_o^f when she is among the oldest cohort. The marital decision for daughters is therefore always taken by their parents. For sons, this decision is taken by their parents during young adulthood and by themselves when they become old adults. I assume a balanced sex ratio by birth cohort, and the population grows at a constant rate a from one cohort to the next. For simplicity, I also assume that each family has only one child, male or female.

Marriage and Bride Price: Each marriage involves the payment of a unique bride price (τ_t) that clears supply and demand in a given market. Markets are assumed to be independent of one another. The equilibrium bride price can be higher in markets with stronger polygyny norms due to the higher demand for brides, as argued in Grossbard (1978) and Goldschmidt (1974). However, this model has no heterogeneity in the supply side of the market. This simplifies the equilibrium matching process. It also avoids taking a stand on whether the type of women who marry as first/unique spouses command a higher or lower bride price payment than those who marry as second spouses since all the brides are assumed to be equivalent in the model. In practice, there is some variation in the amount of bride price payments. Still, the existing evidence does not point toward a systematic difference between first/unique spouses and second spouses.[21] Goldschmidt (1974) for instance, studied bride price payments among several ethnic groups in East Africa and found no difference in bride price of first/unique spouses and second/third spouses. He explains it by the fact that there are two types of men that marry a second spouse. The first type is men with limited resources who are persuaded by social/peer pressure to marry a second time. They can ill-afford it and often seek arrangements that they can handle. They end up marrying less desirable women as second spouses to pay a lower bride price. The second type is rich older men seeking particularly attractive young women and willing to pay more to get one. It is not clear whether there is an overall selection effect in one direction or the other. Allowing for heterogeneity on the supply side will unnecessarily complicate the model and require even stronger assumptions in the absence of data on

[19] Patrilocality or its persistence in the form of sons keeping stronger ties with their family after marriage compared to daughters is the key feature in the model that explains why supply and demand react differently to aggregate shocks.

[20] Having a spouse brings socio-emotional stability, extra labor force, and motivation to a young man.

[21] Lowes and Nunn (2017) also find no evidence that a larger bride price payment is associated with earlier marriage using data from the Democratic Republic of Congo.

actual bride price payments and other relevant bride characteristics at the time of marriage.

I assume that the monetary market is incomplete, and there is no borrowing or savings across periods. The next period is discounted at a rate δ. Each family decides to have their child marry or not when they are young adults or younger (for girls). Old adult sons make their own marital decision because they are emancipated from their parents' household at this age. Parents are authoritarian, not altruistic.

Future Utility: Families derive some utility in future periods from having their child marry by the time they are leaving the marriage market:

- For the groom's family: It captures the future net contributions of their son's family to their own resources. When the parents are too old to work, this can be interpreted as a within-family pension system in which married sons contribute to the consumption of their elderly parents. The presence of sons' offspring provides extra motivation for them to make such contributions to set an example and reinforce the norm for their own future benefit. Importantly, the groom's family does not derive any extra utility from him having a second spouse in my setting because it does not imply higher contributions for them.[22]
- For the bride's family: This can capture contributions from the groom's family, whether occasional (gifts, insurance against adverse shocks, etc.) or regular. These contributions are smaller than the ones the groom's parents receive in patrilocal societies. The bride's family also derive some utility from avoiding the stigma of having an unmarried old daughter.

Let $V_M^{m,f}$ denote the discounted sum of expected utility for a father (or household head) of a son who gets married. $V_M^{m,nf}$ is the discounted sum of expected utility for a son (nf for non-father) who gets married. The decision maker on the supply side is always the girl's father (or household head). V_M^f denotes the discounted sum of expected utility for the parents of a married daughter. V_U^s is the sum of expected utility if a child remains single ($s \in \{m, f\}$) when they exit the market.

Income and Preferences: Household income at period t is the sum of an aggregate income y_t and an idiosyncratic shock ϵ_t: $I_t = y_t + \epsilon_t$. Aggregate income can be high (y^H) or low (y^L) with equal probability each year (depending on aggregate shocks). The idiosyncratic shocks are iid with pdf f. Households have Constant Relative Risk Aversion Utility (CRRA) over consumption each period: $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$, $\gamma \geq 1$.

2.2 Equilibrium Matching Process

At each period t, there are two overlapping generations in the marriage market. It is therefore essential to establish who matches with whom in equilibrium. Multiple equilibria in the matching pattern are possible

[22]This is consistent with the view that marrying a second spouse ensures some continuity in the services that a wife provides in the household (sexual/reproductive services, female-specific household chores, etc.) and signals a certain social status in areas where polygyny is endorsed. The alternative view that polygyny is practiced mainly for economic and productive reasons has little support in the data (Goody, 1973; Fenske, 2013; Lee, 1979; Goldschmidt, 1974).

in theory, but the data seems to support the type of equilibria in which:

- There is an excess quantity of unmarried old men on the market (second participation) at t compared to the quantity of unmarried women of the oldest generation ($\mathcal{U}_o^m > \mathcal{U}_o^f$). This is because many women of this generation have already been married off to older men at $t-1$.
- The unmarried old men on the market can marry women from the youngest or the oldest generation as their unique spouses. They are more willing to pay for a bride than the men of the youngest generation.
- Men from the youngest generation can only marry women from the youngest generation on the market.
- All second spouses are from the youngest generation.[23]

There is a rationing of potential brides, given this matching pattern. This is due to the excess demand for brides compared to the supply despite the marriage age gap and the population growth. Men/women from the oldest generation on the market have the highest willingness to *pay a bride price/accept a bride price* to be matched. All the men from the youngest generation are willing to marry, but their families may not have the resources for it, and they have the outside option of waiting for the next period. For a given bride price, many parents of young girls may want to keep them off the marriage market unless forced financially to do otherwise. The market is therefore cleared by the males and females of the youngest generation on the market. There will be a unique equilibrium bride price in each period for all the women. Households are price takers in this market. The model is solved using backward induction across the two marital decision periods.

2.3 Phase 2: Young/Old Adulthood

Let's denote marital decision at period t by $b_t = 1$ if the child gets married and $b_t = 0$ otherwise. Marital status at the beginning of period t is given by M_{t-1}. It takes the value 1 if the person is married at the beginning of period t. The payoffs for families of "old" children (2nd participation to the market) unmarried at the beginning of period t are:[24]

$$U_{o,t}^f(b_t|M_{t-1}=0, y_t, \epsilon_{it}, \tau_t) = u\big(y_t + \epsilon_{it} + w_o^f + b_t(\tau_t - w_o^f)\big) + b_t V_M^f + (1-b_t)V_U^f$$

$$U_{o,t}^m(b_t|M_{t-1}=0, y_t, \epsilon_{jt}, \tau_t) = u\big(y_t + \epsilon_{jt} - w_o^{m,l} - b_t(\tau_t - w_g^f)\big) + b_t V_M^{m,nf} + (1-b_t)V_U^{m,nf},$$

where $g \in \{o, y\}$.

The payoffs for families of "old" children married at the beginning of t:

$$U_{o,t}^f(b_t|M_{t-1}=1, y_t, \epsilon_{it}) = u\big(y_t + \epsilon_{it}\big) + V_M^f$$

[23]This is the simplest equilibrium supported by the data. The model can easily accommodate other equilibria that are qualitatively equivalent to the one considered here. In particular, it can allow some older women to become second spouses. What matters is that a substantial share of second spouses marries as child brides, and this is the case in the data (see footnote 4, Appendix Figure A11 and A12).

[24]Old adult sons are economically emancipated, so the utility function used here corresponds to their own and not their parents' (unlike for daughters).

$$U^m_{o,t}(b_t|M_{t-1}=1,y_t,\epsilon_{jt}) = u\big(y_t+\epsilon_{jt}+w^{f,1}_o-w^{m,h}_o-b_t(\tau_t-w^{f,2}_y)\big)+V^{m,nf}_M+b_t(V^{m,nf}_{M2}-V^{m,nf}_M).$$

Sons' contribution to their parents' consumption is such that $w^{m,h}_o > w^{m,l}_o$: if unmarried old sons start their own production/consumption unit while being single, they contribute less to their parents' household as discussed in the previous section. $V^{m,nf}_{M2}$ is the discounted sum of expected utility for a son who marries a second spouse.

Any bride price τ_t such that $U^s_{o,t}(b_t=1|M_{t-1}=0,y_t,\epsilon_t,\tau_t) \geq U^s_{o,t}(b_t=0|M_{t-1}=0,y_t,\epsilon_t)$, with $s\in\{m,f\}$ is acceptable for a union to happen between a pair of families. The main incentive for not remaining single comes from the high expected life-time utility that sons (plus their parents) and daughters' parents get when they are married. Old sons already married at the beginning of period t can decide to look for a second spouse with probability p. In this case, they trade-off the extra cost of marrying a second spouse with the expected future utility of having two spouses.

Proposition 1: There exists a non-empty interval $[\underline{\tau}_t,\bar{\tau}_t]$ such that with bride price $\tau^*_t\in[\underline{\tau}_t,\bar{\tau}_t]$, everyone who is single at the beginning of their second participation to the market gets married. Moreover, there is a threshold of idiosyncratic shock $\epsilon^*_{m,2}$ which determines the decision to take a second spouse or not for all the men on the market for a second spouse. Those with $\epsilon_{jt} > \epsilon^*_{m,2}$ are willing to marry again.
Proof: See Appendix Section A.1.1.

The intuition behind the second part of this proposition is that under the concavity assumption in the utility function, richer men have a higher willingness to pay a bride price for a second spouse. Importantly, the threshold $\epsilon^*_{m,2}$ is a decreasing function of the extra utility that men derive from marrying a second spouse $(V^{m,nf}_{M2}-V^{m,nf}_M)$.[25]

2.4 Phase 1: Adolescence/Young Adulthood

Parents are the decision makers at this stage for both boys and girls. For a given bride price τ_t, their payoffs are:

$$U^f_{y,t}(b_t|M_{t-1}=0,y_t,\epsilon_{it},\tau_t) = u\big(y_t+\epsilon_{it}+w^f_y+b_t(\tau_t-w^f_y)\big)+\delta E[\bar{V}^f_{o,t+1}(M_t)]$$

$$U^m_{y,t}(b_t|M_{t-1}=0,y_t,\epsilon_{jt},\tau_t) = u\big(y_t+\epsilon_{jt}+w^m_y-b_t(\tau_t-w^f_y)\big)+\delta E[\bar{V}^m_{o,t+1}(M_t)],$$

where $\bar{V}^s_{o,t+1}$ represents the sum of future utility for parents ($s\in\{m,f\}$). The expectation terms are taken with respect to the future realizations of aggregate income and idiosyncratic shocks. A family with a potential young bride and a family with a potential young groom will want to marry them off if $U^s_{y,t}(b_t=1|M_{t-1}=0,y_t,\epsilon_t,\tau_t)\geq U^s_{y,t}(b_t=0|M_{t-1}=0,y_t,\epsilon_t,\tau_t)$. For any union to happen during stage 1 for a family with a daughter, the bride price has to be higher than the net contribution of their daughter: $\tau_t > w^f_y$. With these constraints, two threshold rules on ϵ_{it} and ϵ_{jt} will determine the quantity of people who find it optimal to marry given aggregate income y_t and bride price τ_t.

Proposition 2: There exist two thresholds of idiosyncratic temporary income, $\epsilon^*_f(\tau_t,y_t)$ and $\epsilon^*_m(\tau_t,y_t)$,

[25] This will play a crucial role in how polygyny affects the equilibrium reaction of marriage markets to aggregate shocks.

which determine the marital decision during the first period of participation in the market. All families on the supply side with $\epsilon_{it} < \epsilon_f^*(\tau_t, y_t)$ and all families on the demand side with $\epsilon_{jt} > \epsilon_m^*(\tau_t, y_t)$ will want to marry off their children.

Proof: See Appendix Section A.1.2

Same intuition as before: Under concavity, the richest families on the demand side want to pay the bride price, and the poorest families on the supply side want to receive it.

2.5 Supply and Demand for Child Brides

Given the equilibrium matching pattern, the demand for child brides comes from three sources:

- Old single men who cannot find an adult spouse because a big share of women in their marriage cohort got already married to older men at $t-1$.
- Potential young grooms whose families received a high enough shock $\epsilon_{jt} > \epsilon_m^*$.
- Old and married men who are looking for a second spouse and received a high enough shock $\epsilon_{jt} > \epsilon_{m,2}^*$ for them to second-marry.

The supply for child brides comes from households with a low enough shock ϵ_{it} for them to marry off their daughters as child brides. This demand and supply of child brides will determine an equilibrium bride price that clears the market. Under concavity, the poorest households with a daughter want to receive a bride price, and the richest ones with a son looking for a spouse want to pay it.

Proposition 3: The demand for child brides is increasing in aggregate income ($D_y = \frac{\partial D(\tau_t, y_t)}{\partial y_t} > 0$) and the supply of child brides is decreasing in aggregate income ($S_y = \frac{\partial S(\tau_t, y_t)}{\partial y_t} < 0$). Moreover, the demand for child brides is decreasing in bride price ($D_\tau = \frac{\partial D(\tau_t, y_t)}{\partial \tau_t} < 0$) and the supply of child brides is increasing in bride price ($S_\tau = \frac{\partial S(\tau_t, y_t)}{\partial \tau_t} > 0$).

Proof: See Appendix Section A.1.3

Proposition 4: If the extra utility that men derive from marrying a second spouse ($V_{M2}^{m,nf} - V_M^{m,nf}$) is high enough, lower aggregate income will increase the market shares of young men that are looking for first/unique spouses at the expense of older ones that are looking for second spouses.

Proof: See Appendix Section A.1.4.

The threshold for marrying a second spouse ($\epsilon_{m,2}^*$) is a decreasing function of $V_{M2}^{m,nf} - V_M^{m,nf}$. When the latter is high enough, concavity implies that the demand for second spouses will be more sensitive to the income and price changes when aggregate income is low compared to the demand for first/unique spouses. In other words, the demand for second spouses is more elastic to income and price changes when the marginal man who finds it optimal to marry a second spouse is not too "rich" ($\epsilon_{m,2}^*$ low enough). This is likely to be the case in many areas of Sub-Saharan Africa, where polygamy is not just practiced by the rich elite but is also almost equally common among less rich and poorer men. Appendix Figure A3 and A4 show, for instance, that there is a similar proportion of polygamous households across all the wealth quintiles in my sample. It has also been documented in the literature that many polygamous men are relatively poor. They tend to face even higher levels of economic stress and anxiety compared to monogamous men (Heath et al., 2020; Boltz and Chort, 2019; Antoine et al., 2002).[26] Polygamy being common even among even relatively poor men is also consistent with the view that those men second-marry mostly because of social pressure and because they value a lot having some continuity in the services that women provide in the household (sexual, reproductive, and other domestic services).[27]

Proposition 5: Lower aggregate income increases child marriage in equilibrium when polygyny is not allowed $\left(Q^*_y = \frac{dQ^*(y_t)}{dy_t} < 0\right)$. In presence of polygyny, this increase in child marriage is weaker as p increases $\left(\frac{dQ^*_y}{dp} > 0\right)$ when $V^{m,nf}_{M2} - V^{m,nf}_{M}$ is high enough.
Proof: See Appendix Section A.1.5.

In monogamous markets ($p = 0$), the overall effect of a negative aggregate economic shock depends on the differences in income-elasticity and price-elasticity of supply and demand for child brides. As shown in the proof (following similar arguments as in Corno et al. (2020)), $sgn\Big(Q^*_y = \frac{dQ^*(y_t)}{dy_t}\Big) = sgn\Big(\frac{S_y}{S_\tau} - \frac{D_y}{D_\tau}\Big) < 0$. The increase in child marriage comes from the fact that the ratio of income to price-elasticity of the supply is higher (in absolute value) than the ratio of income to price-elasticity of the demand since $\epsilon^*_m > \epsilon^*_f$ when $w^{m,l}_o$ is high enough. This is likely the case in patrilocal societies.

For the second part, I show that when $p > 0$ (polygamous markets):

$$sgn\Big(\frac{dQ^*_y}{dp}\Big) = sgn\Big[\frac{dD_y}{dp}(S_\tau - D_\tau) - \frac{dD_\tau}{dp}(S_y - D_y)\Big] > 0.$$

The threshold for marrying a second spouse $\epsilon^*_{m,2}$ is a decreasing function of the extra utility that men derive from having a second spouse ($V^{m,nf}_{M2} - V^{m,nf}_{M}$). When this difference is high enough, the income to price-elasticity ratio is higher (in absolute value) for the demand for second spouses compared to the demand for first/unique spouses, which explains the positive sign.[28] This leads to an attenuation of the overall effect of an income shock on the equilibrium quantity of child marriage. A higher share of men on the market for second spouses (captured by higher p) will translate into more weight for the demand for second spouses leading to more attenuation in the overall effect.

Figure 2 illustrates the comparative statics regarding child marriage. Panel (a) shows the case of monogamy. Child marriage increases when aggregate income is low because the supply curve is more income-elastic than the demand (both curves have similar price-elasticities here).[29] When polygyny

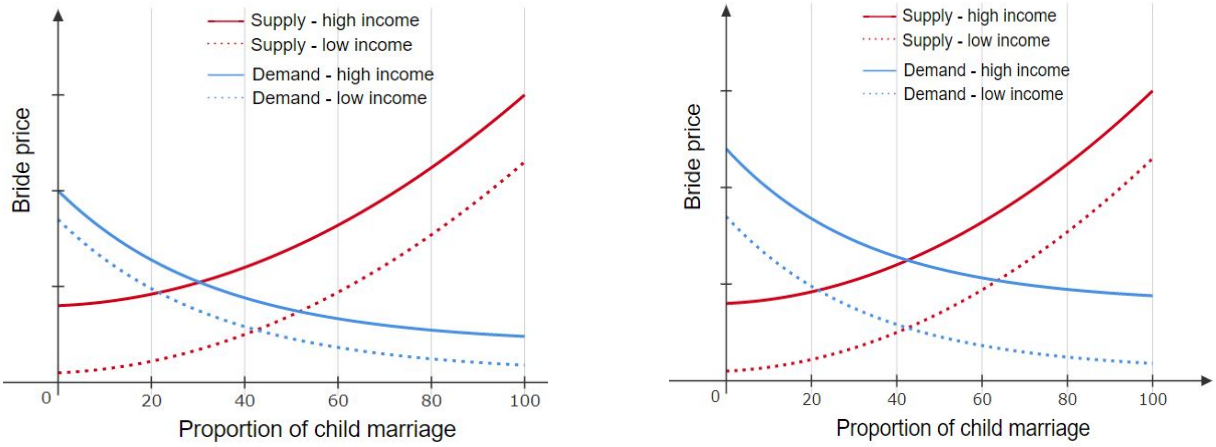
[26]Marrying a second spouse still requires resources, and some of the poorest men will not be able to afford it throughout their life.

[27]Goldschmidt (1974) documents some strong peer pressure in favor of polygyny in many ethnic groups of East Africa, and this often takes the form of mockery and derision. This is well captured in popular proverbs such as this one from the Sebei ethnic group (present in Uganda): "a man with one wife is a neighbor to a bachelor," which means that if the wife is unavailable (sickness, death, etc.), he must do the household chores himself.

[28]In the presence of polygyny, the overall elasticity of the demand to the income and price drop that comes with low aggregate income is, therefore, closer to the overall elasticity of the supply.

[29]Price-elasticity corresponds to the slope of the curves, and the income-elasticity corresponds to the horizontal shift that happens to each curve when income is low or high.

Figure 2: Illustration of the Comparative Statics



(a) Monogamy (b) Polygamy

is allowed (panel (b)), the income-elasticity of the overall demand is much higher than in the case of monogamy because of the demand for second spouses. This elasticity is, therefore, closer to the one of the supply curve, leading to a much weaker increase in the equilibrium quantity of child marriage when there is a negative shock. Panel (b) shows a particular case in which the supply and demand have the same income-elasticity (on top of having the same price-elasticity), so there is no change in the equilibrium quantity of child marriage.

Testable Predictions: Proposition 4 and 5 are the main testable predictions of the model that I take to the data. A third testable (implicit) implication of the model is that households and markets should react symmetrically to positive and negative aggregate shocks. To test these three predictions, I exploit the persistent spatial variation in the extent to which polygyny is practiced in Sub-Saharan Africa. The variation in p across space is assumed to be orthogonal to any potential variation in the extra utility that men derive from marrying a second spouse ($V_{M2}^{m,nf} - V_{M}^{m,nf}$). One can think of it as having similar geographic areas, with the only difference being that some of these areas have high p because of a combination of persistent factors such as traditional norms, religion, slave trade, colonial institutions, and other historical events as argued in Section 3.4.3.[30]

3 Data and Descriptive Evidence

This section provides a general overview of the different datasets used to test the model's predictions. It also discusses some key descriptive evidence.

[30]The rural-urban divide is, for instance, one source of variation in p that may be linked to differences in $V_{M2}^{m,nf} - V_{M}^{m,nf}$ but the empirical exercise in this paper does not rely on this kind of variation.

3.1 Marriage, Ethnicity, and Religion Data

The main data source is the Demographic and Health Survey data (DHS). DHS surveys are nationally-representative household-level surveys carried out regularly in several developing countries worldwide. The final dataset assembles all the publicly available DHS surveys in Sub-Saharan Africa between 1994 and 2013, where geocoded data are available, resulting in a total of 73 surveys across 31 countries. In all the surveys, the information on a woman's age at first marriage is collected retrospectively during the interview.[31] All the women between the ages of 15 and 49 are interviewed in the survey.

The analysis is restricted to the sample of women who are at least 25 years old at the time of the interview. Women exposed to major civil conflicts in the ages relevant for each empirical specification are also dropped in the main analysis. UCDP/PRIO Armed Conflict Dataset is used to identify the onset and the end of the main conflicts in Sub-Saharan Africa. The GPS coordinates of each DHS household cluster are used to match it with its corresponding 0.5×0.5 decimal degree weather cell grid. This is then used to measure each survey respondent's exposure to droughts and crop price shocks over time.

Information on whether each woman is married to a polygynous husband or not and her rank in this union (first spouse, second spouse, etc.) is also collected in most, but not all, DHS surveys. I use this information in the analysis to construct a measure of the extent to which polygyny is practiced in each weather grid cell. This measure is the polygyny rate, defined as the share of women aged 25 or older who are married to a polygynous husband. I also use the information on religion, which is available for most DHS surveys. The codes for religion are country-specific, and I harmonize them into three main groups: Christians, Muslims, and Animists/other religions. There is a link between religious beliefs and the practice of polygyny. Polygyny is formally forbidden in most Christian religions and accepted/tolerated (sometimes even encouraged) in Islam and most traditional religions in Sub-Saharan Africa. There is, however, a substantial variation between religion and the practice of polygyny across space. This allows me to check that my results are not driven by religion per se. The information on ethnic groups in the DHS is also used to merge the data with pre-colonial ethnic characteristics such as the presence of bride price payment and the kinship system from the Atlas of Precolonial Societies (Murdock, 1967; Nunn, 2008; Müller et al., 2010).

3.2 Rainfall Data and Construction of Rainfall Shocks

Rainfall data produced by geographers at the University of Delaware ("UDel data") is used to construct a measure of local rainfall shocks. The UDel data set provides estimates of monthly precipitation on a 0.5×0.5 decimal degree grid cell covering terrestrial areas across the globe for the 1900–2010 period. Following the literature, a drought is defined as a calendar year rainfall below the 15th percentile of a grid cell's long-run rainfall distribution (Corno et al., 2020; Burke et al., 2015).[32] I also explore robustness

[31] Validation studies show that women's recollection of marriage year is accurate enough, so the estimated results that use this information are not likely to be substantially downward-biased (Pullum, 2006).

[32] The long-run time series of rainfall observations are used to fit a gamma distribution of calendar year rainfall for each location.

around that threshold and to using a continuous rainfall measure. The GPS information in the DHS data matches each cluster to a weather grid cell. The final sample contains over 3,000 individual grid cells.

This drought measure has two key properties that help in identifying the impact of rainfall shocks on family formation outcomes. First, it has a sizable impact on crop yields, and rainfall variation essentially generates a negative aggregate income shock. As shown in Appendix Figure A14, the lowest deciles of rainfall realizations are associated with a substantial drop in crop yield (10% on average) but there is no clear positive relationship between higher rainfall realizations and country-level crop yields. Second, this measure of rainfall shock is orthogonal to permanent local characteristics that are likely to influence family formation outcomes. If rainfall realizations are i.i.d., all locations will have the same probability (15%) of experiencing a shock in any given year. The identifying variation comes only from the random timing of the shocks.

3.3 Commodity Price Shocks

Following McGuirk and Burke (2020), I construct local price series that combine plausibly exogenous temporal variation in global crop prices with spatial variation in crop production and consumption patterns. The price data comes from the IMF (International Monetary Fund) *International Finance Statistics series* and the World Bank *Global Economic Monitor.* Figure A1 shows the evolution of the price index for the three main food crops (maize, wheat, and rice) and cash crops (coffee, cocoa, and tobacco) for African consumers and producers. There is substantial variation in prices for the period 1989–2013, with notable spikes around 1995 and during the recent world food price crisis in 2007-2008 and 2010-2011. Africa accounts for less than 6% of global cereal production, and it is unlikely that local phenomena happening on the continent would affect world prices. Global commodity prices tend to go through several years of boom and bust during commodities supercycles. The recent spikes in global food prices around 2007 and 2010 were, for instance, driven by factors such as weather shocks in main supplier countries (Australia, China, Latin America, etc.) and demand shocks from booming economies (China, Latin America, etc.) (World Bank, 2014). It is unlikely that any of these factors would drive aggregate income and marital outcomes in opposite directions for rural and urban areas, as predicted in the model, other than through their effect on world food prices.

3.3.1 Producer Price Index (PPI)

The producer price index (PPI) is obtained by combining the temporal variation in world prices with rich, high-resolution spatial variation in crop-specific agricultural land cover around the year 2000 from the M3-Cropland project (see Ramankutty et al. (2008) for more details).[33] The PPI in year t for cell g located in country c is given by:

$$PPI_{gct} = \sum_{j=1}^{n} \left(\pi_{jt} \times N_{jgc}\right) \tag{1}$$

[33]Appendix Figure A2 presents crop specific geographic distribution for a selection of six major commodities (maize, rice, wheat, sorghum, cocoa, and coffee).

where $j = 1, .., n$ represents a crop in a list of 11 major traded crops that are in the M3-Cropland dataset and for which international prices exist. N_{jgc} represents crop j's share of land in cell g and π_{jt} the global price index for this crop in year t. The index varies over time only because of plausibly exogenous international price changes. Following McGuirk and Burke (2020), I also define PPI_{gct}^{food} as a producer price index for food crops (those that constitute more than 1% of calorie consumption in the entire sample) and PPI_{gct}^{cash} as an index of prices for cash crops (the rest).

3.3.2 Consumer Price Index (CPI)

The CPI is constructed in a similar spirit, but the spatial variation comes from country-level data on food consumption in the FAO food balance sheets (see McGuirk and Burke (2020) for more details). The CPI in year t for country c is given by:

$$CPI_{ct} = \sum_{j=1}^{n} \Big(\pi_{jt} \times S_{jc}\Big), \tag{2}$$

where crops $j = 1, ..n$ are contained in a set of 18 crops consumed in Africa and for which world prices exist, making up 56% of calorie consumption in the sample.[34]

3.4 Variation in the Practice of Polygyny in Sub-Saharan Africa

3.4.1 Practice of Polygyny over Time

I first investigate the evolution of country-level polygyny rates over time. Appendix Figure A13 shows the share of women (aged 25 and older) in union with a polygynous husband. I restrict the sample only to unions that happened within the last 10 years before each DHS survey wave .[35] Most countries have more than one wave, and the graph shows some stability in the practice of polygyny. The proportion of polygynous unions within the last 10 years is constantly low in countries like Madagascar (below 5%) and, to a lesser extent, in Rwanda, Zambia, Zimbabwe, and Namibia (below 10%). Monogamy is by far the norm in these countries, and polygyny is rather marginal or practiced in very few areas within each of them. Polygyny rates are also fairly constant (or decline very slightly) for countries with intermediate levels of polygyny (between 10 and 25 %), such as Cameroun, the Democratic Republic of Congo (former Zaire), Ethiopia, and Kenya. There is, at best, a slow decline in the proportion of polygynous unions that occurred within the last 10 years for countries with high levels of polygyny, such as Benin, Burkina Faso, Mali, and Guinea. This decline (when there is one) is such that these countries still have higher levels of polygyny around 2015 than what those with a medium level of polygyny had around 1995.

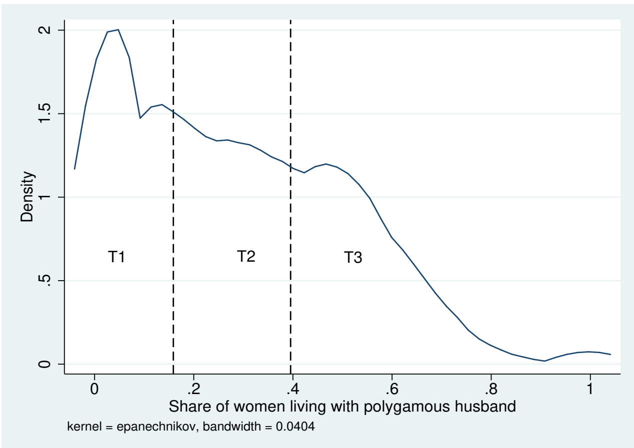
[34]The list includes important staples such as maize, wheat, rice, and sorghum, as well as sugar and palm oil, which are used to process other foods.

[35]This is a flow variable since DHS waves are at least 5 years apart from each other and there is a minimum of 10 years between first and last DHS waves for most countries. The levels are lower than what we get with the stock variable since this ratio mostly counts second spouses in the numerator by construction.

3.4.2 Spatial Variation in the Practice of Polygyny

Here I investigate the spatial variation in the practice of polygyny. I aggregate all available waves of the household survey data in the main sample into cell-level data. For each 0.5 × 0.5 decimal degree cell grid in the sample, I compute the share of females aged 25 and older that report being in union with a polygynous husband.[36] Figure 3 shows the distributions of all the grid cells by polygyny rate. It shows a substantial variation in the practice of polygyny across cells. The bottom tercile (T1) is the group of low polygyny grid cells (less than 16%), and the top tercile is the group of high polygyny grid cells (more than 40%). The cells with polygyny rates between 16 and 40% are areas with medium polygyny rates. More than 15% of the 3,201 grid cells (precisely 504 of them) have zero polygyny rate, and the rest of the bottom tercile have a polygyny rate between 0 and 16%. Monogamy is the local norm in the marriage markets in these cells. On the other side of the spectrum, around 18% of all cells have a polygyny rate higher than 50%. In the main analysis, I use the continuous rate to measure the extent to which polygyny is practiced in each area. To simplify the quantification of the estimated effects and focus on major variations in the practice of polygyny, I also use the discretized measure (terciles). I show moreover robustness to using only the first and the last available DHS survey to compute the polygyny rates (10 years on average in between). Murdock's Ethnographic Atlas provides some historical information on the practice of polygyny in Africa. Polygyny is reported for 95% of ethnic groups, and there is no information on the intensity at which it occurred in those societies. This historical information is, therefore, not enough to capture the substantial spatial variation in the contemporary practice of polygyny across Sub-Saharan Africa.

Figure 3: Kernel Density Estimation of the Distribution of Cell-Grids by Polygyny Rate



Note: Polygyny rate is the share of women aged 25 and older that are in a union with a polygynous male in each 0.5 × 0.5 decimal degree weather grid cell. T1 represents grid cells with low polygyny (less than 16%), T2 is for areas with medium polygyny (between 16 and 40%), and T3 is for areas with high polygyny (more than 40%).

Figure 1 shows the spatial dispersion of grid cells with low, medium, or high polygyny rates based on DHS data. These levels are represented in green, yellow, and red, respectively. It shows substantial

[36] Information on the presence of potential co-spouses is collected in DHS surveys that cover 3,201 grid cells out of the 3, 250 cells that are in the main sample.

variation across regions. Polygyny is more common in West Africa, as shown by the red corridor that goes from Senegal and Guinea to Nigeria through countries like Mali, Burkina Faso, Benin, and Togo. Polygyny is less prevalent in Central, Eastern, and Southern African countries. There are, however, important variations within each country.

In some West African countries, such as Burkina Faso and Guinea, we have a sea of red cells (high polygyny) with a few islands of yellow cells (the main urban centers). In others, we have the three polygyny levels that appear compactly and progressively when we move from one side of the country to another. This is the case, for instance, in Ghana, where the North has high polygyny rates, the Center has medium polygyny rates, and the South has low polygyny rates. Most countries in Central Africa also have a mix of cells with all three polygyny levels but much less clustering in space. This is the case for countries like the Democratic Republic of Congo and Tanzania. In other countries such as Madagascar and Eritrea, we have a sea of green grid cells (low polygyny) with a few islands of yellow and red cells. Lesotho is the only country where all the cells are green. Polygyny rates are lower than 7% in all areas in this country.

The practice of polygyny is, therefore, a very local norm with a spatial pattern that varies substantially across countries/regions.[37] I take these local norms as given in the analysis and try to understand how this might affect the equilibrium outcomes in the marriage market when there is a temporary aggregate economic shock.

3.4.3 Source of Heterogeneity in Polygyny Norms

The determinants of polygyny have been the focus of an extensive theoretical and empirical literature in economics. Among the factors considered in the literature there is income inequality (male competition), slave trade, religion, education, colonial missions and schools, pre-colonial ethnic customs, female productivity, etc. (Boserup, 1970; Becker, 1974; Jacoby, 1995; Gould et al., 2008; Fenske, 2015; De La Croix and Mariani, 2015; Alger, 2021). In particular, Fenske (2015) has shown that historical factors explain more the spatial variation in the practice of polygyny compared to contemporary ones. It shows, for instance, that modern female education does not reduce polygamy, but colonial schooling does.[38] The documented variation in the practice of polygyny can only be explained by a combination of most (if not all) of the historic factors mentioned above. No single factor can explain all the variations in the practice of polygyny. Two of the most important factors that generate a substantial variation in polygyny norms are religion (Islam and traditional religions versus Christianity) and kinship systems (patrilineal versus matrilineal). I

[37] Given the country/regional differences in the spatial pattern of polygyny rates, I check in Section 5.8.2 that my results hold for different sample restrictions across space.

[38] An earlier version of this paper (Fenske, 2013) also shows that past inequality (historic class stratification) predicts polygamy today but not current inequality and polygamy varies smoothly over borders along ethnic lines despite national bans in some countries. It also argues that the link between women's productivity in agriculture and polygamy (Boserup, 1970; Jacoby, 1995) plays a minor role in explaining the spatial variation in polygyny norms in Africa. Polygamy is least common in those parts of Africa where women have historically been most influential in agriculture. Anthropologists have made this claim much earlier by noting, for instance, that the level of polygyny is highest in West Africa, and yet it is in East Africa that women engage more in agriculture (Goody, 1973).

use the variation in the joint distribution of polygyny and each of these factors across space to check that they do not drive my main results (see Section 5.5 and Appendix Section A.2.1 for more details).

4 Empirical Strategy

4.1 Prediction 1: Polygyny, Droughts, and Types of Unions

The first prediction of the model is that in the presence of polygyny, adverse aggregate shocks should increase the market shares of young men that are looking for first/unique spouses at the expense of older men that are looking for second spouses. This means that women exposed to droughts should be more likely to marry younger men as first/unique spouses. I test this prediction in two ways. First, I check whether this is the case for women who experience a drought between ages 12 and 24 (peak marriageable age) using the following specifications:

$$Y_{i,g,k,\tau} = \alpha D_{i,g,k} + \theta D_{i,g,k} \times P_g + \omega_g + \gamma_k + \delta_\tau + \epsilon_{i,g,k,\tau}, \tag{3}$$

$$Y_{i,g,k,\tau} = \alpha^l D^l_{i,g,k} + \alpha^m D^m_{i,g,k} + \alpha^h D^h_{i,g,k} + \omega_g + \gamma_k + \delta_\tau + \epsilon_{i,g,k,\tau}. \tag{4}$$

$Y_{i,g,k,\tau}$ represents the union characteristics: age gap with the husband or whether woman i gets married as a junior spouse (second spouse or higher order spouse). The variable $D_{i,g,k}$ is a dummy equal to 1 if woman i born in cell g in year k has been exposed to a drought between ages 12 and 24. P_g is the average polygyny rate of the cell g in which female i lives. It captures the long-term social norm in the practice of polygyny for a given area. ω_g is a set of location fixed effects included to account for time-invariant local unobservable characteristics such as geographic, economic, and cultural factors. γ_k and δ_τ are year-of-birth fixed effects and marriage year fixed effects. They account for cohort effects and marriage year effects, such as exposure to any common shock at a specific time. Sampling weights reweighted by each country's population in the survey year are used to make the results representative of the countries included in the analysis. Standard errors are clustered at the grid-cell level to allow for serial correlation in the error terms across women in the same area.

A drought is defined as a calendar year rainfall below the 15th percentile of that location's historical rainfall distribution. This implies that all the locations have the same probability of experiencing a drought in any given year, but its timing is random. By construction, exposure to a drought within a fixed time window should be orthogonal to unobserved local characteristics. The identifying variation comes from the random timing of the shocks. The extent to which polygyny is practiced in Sub-Saharan Africa is determined by a combination of historical factors, as argued in Section 3. The time-invariant variation in polygyny rates (P_g) is absorbed by the location fixed effects and orthogonal to time-varying shocks.

To simplify the interpretation of the coefficients and stress the fact that identification relies only on the substantial spatial variations in polygyny rates, I also discretize the continuous variable P_g into terciles and run the specification in Equation 4.[39] The variation over time in polygyny rates is such that almost all the cells remain in the same tercile over the 20 years of DHS data.[40] The model predicts that exposure to droughts decreases the spousal age gap only in polygamous areas, and it decreases the likelihood of marrying into a polygamous household (as second spouse) in these areas: $\alpha = 0$ and $\theta < 0$ in Equation 3 or at least $\alpha^h < 0$ and $\alpha^l = 0$ in Equation 4.

Not all the women exposed to a drought will marry in the same year the drought occurred, and this may lead to some attenuation bias in the previous specifications. In a second approach for testing this prediction, I compare the characteristics of unions for women that marry during droughts to those that marry in standard years as described in Appendix A.3.

4.2 Prediction 2: Polygyny, Droughts, and Marriage Timing

The second prediction of the model is that droughts should have a weaker impact on the timing of marriage in more polygamous areas. I test this prediction of the model using two different estimation frameworks. The first one relies on a simple discrete approximation of a duration model adapted from Currie and Neidell (2005) following Corno et al. (2020). The duration of interest is the time between $t_0 = 12$, the age when a woman is first at risk of getting married, and t_m, the age when she enters her first marriage. The original data is converted into person-year panel format. A woman married at age t_m contributes $(t_m - t_0 + 1)$ observations to the sample: one observation for each at-risk year until she is married, after which she exits the data. Since I am interested in early marriage, I examine data on women until age 24 or 17, depending on the specification.[41] This data is then merged with the yearly rainfall data. Since marriages occur uniformly during a given year in Sub-Saharan Africa, the merge is done considering the calendar year in which a woman is of age t. This person-year sample allows us to estimate a hazard model to study how rainfall shocks can affect the timing of unions using the following specifications:

$$M_{i,g,k,a(t)} = \beta D_{g,k,a(t)} + \gamma D_{g,k,a(t)} \times P_g + Z_a + \omega_g + \gamma_k + \epsilon_{i,g,k,a(t)}. \quad (5)$$

$$M_{i,g,k,a(t)} = \beta^l D^l_{g,k,a(t)} + \beta^m D^m_{g,k,a(t)} + \beta^h D^h_{g,k,a(t)} + Z_a + \omega_g + \gamma_k + \epsilon_{i,g,k,a(t)}. \quad (6)$$

The dependent variable $M_{i,g,k,a(t)}$ is a binary variable coded as 1 in the year the woman gets married. $D_{g,k,a(t)}$ is a time-varying measure of weather conditions (dummy for a drought) in location g during the calendar year t in which the woman born in year k is of age a. P_g is the average (long-term) polygyny rate of the cell g in which female i lives. Z_a is a vector of age fixed effects that control for the fact that marriage hazard varies by age. ω_g is a set of location fixed effects, and γ_k is a set of year-of-birth fixed

[39]The superscript l stands for low polygyny area (bottom tercile), m for medium and h for high polygyny area (top tercile).

[40]Appendix Figures A13 show the evolution of polygyny rates over time. Even from this country-level aggregation, we can see that the decline observed in some of the countries with high polygyny rates is very modest and keeps them above the polygyny rates in those with low and medium levels.

[41]The data is right-censored for females that marry after age 24 for the early marriage specification and age 17 for the child marriage specification.

effects. The impact of weather shocks on the hazard of child marriage is identified from within-location and within-year-of-birth variation in weather shocks and marriage outcomes. The model predicts $\beta > 0$ and $\gamma < 0$ (or equivalently $\beta^l > \beta^m > \beta^h$ and at least $\beta^l > 0$). This is also a confirmation of the model's first prediction because the attenuation effect is a direct consequence of the higher elasticity of the demand for second spouses to income and price changes.

The second estimation framework is an alternative to the hazard model. It looks at the impact of exposure to any drought between age 12 and 17 (or age 24) on the likelihood of marrying before age 18 (or age 25) using specifications similar to the ones in Equation 3 and 4 (the ones used to test prediction 1). Both approaches show consistent results, as discussed below.

4.3 Prediction 3: Symmetric Reaction to Positive Shocks

To test whether households and markets react in a symmetric way to positive and negative shocks, I evaluate the impact of crop price shocks on family formation outcomes. For the case of the hazard of early marriage, the estimating equations are:

$$
\begin{aligned}
M_{i,g,k,a(t)} &= \beta^F PPI_{g,k,a(t)} + \gamma^F PPI_{g,k,a(t)} \times P_g + \beta^C CPI_{c,k,a(t)} + \gamma^C CPI_{c,k,a(t)} \times P_g \\
&+ Z_a + \omega_g + \gamma_k + \mu_t + \eta_c \times t + \epsilon_{i,g,k,a(t)}. \qquad (7)
\end{aligned}
$$

$$
M_{i,g,k,a(t)} = \beta^F PPI_{g,k,a(t)} + \gamma^F PPI_{g,k,a(t)} \times P_g + Z_a + \omega_g + \gamma_k + \eta_{ct} + \epsilon_{i,g,k,a(t)}. \qquad (8)
$$

PPI is the producer price index; CPI is the consumer price index; μ_t are calendar year fixed effects; $\eta_c \times t$ are country-specific time trends, and η_{ct} are country×year fixed effects. The model predicts $\beta^F < 0$ and $\gamma^F > 0$ for PPI and $\beta^C > 0$ and $\gamma^C < 0$ for CPI. In Equation 7, the identifying assumption is that, after accounting for all the fixed effects and country-level trending factors, PPI and CPI shocks are not correlated with unobserved factors that could be affecting marital decisions. A more demanding specification is to replace year fixed effects and country-specific time trends by country×year fixed effects as shown in Equation 8. The coefficients are estimated in this case from the within-country-year variation in prices and marriage timing (preferred specification). This comes at the cost of not being able to include the CPI term since it only varies at the country level. Accounting for common trending factors is important here because the price index displays some clear trends that can easily be correlated with other confounders.[42]

[42]This is not the case for droughts (their timing is i.i.d.), so there is no need to absorb time effects in the baseline hazard. I nevertheless show that the results are robustness to accounting for time effects with the exact specifications used for PPI and CPI when testing the impact of droughts on the hazard of child marriage (see results in Appendix Table A20).

5 Empirical Results

5.1 Prediction 1: Polygyny, Droughts, and Types of Unions

Table 2 reports the estimated coefficients for Equation 3 and 4. Column (1) shows that exposure to a drought between ages 12 and 24 has no effect on the husband-wife age gap in monogamous areas (α close to zero and statistically insignificant) but significantly decreases it in areas where polygyny is more commonly practiced (interaction term θ is negative and significant at 1% level). Column (2) shows the average impact for low, medium, and high polygyny areas (the terciles of the continuous polygyny rate). Droughts have no detectable effect in low and medium polygyny areas on average, but they decrease the husband age gap by 1.2 years in high polygyny areas (10% of the average gap, p<0.01). Column (4) controls for age at first marriage, and the estimates remain stable. Columns (5) and (6) also show that droughts decrease the likelihood of marrying as a junior spouse (second spouse or higher as opposed to marrying as first/unique spouse) in high polygyny areas. Column (8) restricts the sample to women in a polygamous union in low or high polygyny areas.[43] It shows that droughts decrease the likelihood of marrying as a junior spouse by 3.2 percentage points (pp) which represents 6% of the average probability of marrying as a junior spouse in that sample (p<0.01). Columns (3) and (7) split the window of exposure into exposure to a drought in the age range 12-17 and in the age range 18-24. The pattern of results holds for the two outcomes within both age windows.

These estimates are therefore consistent with the first prediction of the model: women exposed to a drought are more likely to marry younger men only in polygynous areas and as first/unique spouses. The results are qualitatively the same when I use the alternative specification in which I compare the characteristics of unions that occur during drought years to those that did not, as discussed in Appendix A.3 (see Table A1). Women who got married during a drought year have a smaller spousal age gap only in high polygyny areas (age gap decreases by 0.34 years, p<0.05), and they are less likely to marry as junior spouses (decrease of 2 pp in the likelihood of being a junior spouse, p<0.05).

5.2 Prediction 2: Polygyny, Droughts, and Marriage Timing

I test the second prediction of the model by using the estimation frameworks described in Section 4.2. I discuss the hazard model first. Column (1) of Table 3 shows estimation results using the specification in Equation 5. The coefficient β on the main regressor is positive and significant (p-value<0.01), while the one on the interaction term γ is negative and significant (p-value<0.05). Girls who experience a drought in monogamous areas are 0.75 percentage points more likely to get married that same year, which corresponds to an increase of 6.2% in the average annual hazard of marriage for this age group. This is twice the average effect for Sub-Saharan Africa that is documented in Corno et al. (2020) (see replication

[43]Droughts do not affect the probability that a woman ends up in a polygamous union. Marrying a young bachelor as a first spouse does not imply that he will not marry another spouse a few years down the road.

Table 2: Polygyny, Exposure to Droughts, and Types of Unions

	Husband age gap				Junior wife (2nd wife or higher order)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Any drought ages 12-24 x low polygyny		0.0297		0.0271		0.0123		
		(0.3129)		(0.3130)		(0.0077)		
Any drought ages 12-24 x medium polygyny		0.0735		0.0739		-0.0096		
		(0.2493)		(0.2494)		(0.0093)		
Any drought ages 12-24 x high polygyny		-1.2137***		-1.2113***		-0.0245**		
		(0.2603)		(0.2606)		(0.0115)		
Any drought ages 12-24	0.3799				0.0096			-0.0317***
	(0.3007)				(0.0089)			(0.0122)
Any drought ages 12-24 x polygyny rate	-2.4957***				-0.0581**			
	(0.7842)				(0.0286)			
Any drought ages 12-17 x low polygamy			-0.1019				0.0140*	
			(0.3100)				(0.0075)	
Any drought ages 12-17 x medium polygamy			0.0680				-0.0108	
			(0.2560)				(0.0095)	
Any drought ages 12-17 x high polygamy			-1.3118***				-0.0240**	
			(0.2662)				(0.0117)	
Any drought ages 18-24 x low polygamy			0.2264				0.0095	
			(0.3234)				(0.0090)	
Any drought ages 18-24 x medium polygamy			0.0709				-0.0072	
			(0.2545)				(0.0103)	
Any drought ages 18-24 x high polygamy			-0.9543***				-0.0258**	
			(0.3013)				(0.0124)	
Age at first marriage				-0.0625				
				(0.0696)				
Observations	224,936	224,936	224,936	224,936	226,130	226,130	226,130	71,149
Adjusted R-squared	0.1516	0.1517	0.1518	0.1517	0.0815	0.0815	0.0815	0.0637
Mean dependent variable	9.975	9.975	9.975	9.975	0.175	0.175	0.175	0.516

OLS regressions with observations at the individual level. The full regression sample includes married women aged 25 or older at the time of the survey. The dependent variables are the husband-wife age gap (columns 1-4) and whether a woman married as a junior wife (columns 5-8). All regressions include birth year FE, marriage year FE, and grid-cell FE. Column (8) restricts the sample to women in polygynous unions in medium and high polygyny areas. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. The average husband-wife age gap is 6.81, 9.48, and 13.02 years in low, medium, and high polygyny areas, respectively. All regressions are weighted using country population-adjusted survey sampling weights.

in Table A3).[44] This effect is fading out substantially as we move to areas with higher rates of polygyny. Assuming this decay is linear, results in column (1) suggest that the causal impact of droughts on the hazard of early marriage is halved for women living in areas with polygyny rates around 30% (medium level of polygyny) and vanishes completely for those living in areas with polygyny rates around 50% (high level of polygyny). This means that droughts have a much weaker impact on the hazard of early marriage in more polygynous areas, as predicted by the model.

The results confirm this in column (2), where I estimate the specification in Equation 6. The estimated impact of droughts on the annual hazard of early marriage goes from 0.64 percentage points for low polygyny areas (bottom tercile) to 0.38 percentage points in areas with medium polygyny levels (middle tercile). Both estimates are significantly different from zero at 1% and 5% significance levels, respectively. For women living in high polygyny areas (top tercile), the estimated effect is close to zero and statistically insignificant. Columns (3) and (4) show the same attenuation pattern when I consider the hazard of marrying between ages 12 and 20 or between ages 12 and 17 (child marriage), respectively. I then split the sample of women according to whether bride price is practiced or not in their ethnic group in columns (5) and (6).[45] The results confirm the attenuation pattern only in ethnic groups that require some form of

[44]The impact reported in Corno et al. (2020) underestimates the true effect of droughts on the annual hazard of early marriage in monogamous markets substantially.

[45]This excludes all the observations with missing information on bride price practice.

bride price payment to celebrate a union. There is no effect of droughts on the timing of marriage among women from ethnic groups that do not practice bride price payments, irrespective of whether polygyny is common.

Estimates from the duration model, therefore, show that women exposed to a drought in a given year between ages 12 and 24 (or 12 and 17) are more likely to get married the same year, but the presence of polygyny attenuates this effect. This weaker link between droughts and child marriage comes from the demand for second spouses (by older men) being more elastic to the income and price drop that occurs when there is a drought, as shown in the previous section. The income and price elasticity of the overall demand and supply of child brides are therefore closer to each other when polygyny norms are stronger. This attenuation is such that droughts have no detectable impact on child marriage in high polygyny areas.

An alternative specification to the hazard model is to estimate the impact of being exposed to any drought between ages 12 and 17 (or 24 for early marriage) on the likelihood of marrying by that age. Each observation is an individual woman in this specification instead of the *person* $\times$ *age* level data used in the duration model. The results of this specification are presented in Table A2 and are consistent with those from the duration model in Table 3 (see Appendix Section A.4). The hazard model presents the advantage of linking droughts in a given year to the likelihood of marrying that same year (not before or after). This creates a much sharper identifying variation that rules out other potential confounders, as argued below. Further robustness checks are also discussed in the next sections.

5.3 Prediction 3: Polygyny, PPI/CPI, and Marital Outcomes

In this section, I evaluate the impact of global crop price variation on marital outcomes. Table 4 shows the results of the specification in Equation 8 and includes *country* $\times$ *year* fixed effects (omits therefore the CPI).[46] Columns (1) and (2) use the whole sample and show that a rise in PPI significantly decreases the hazard of early marriage in monogamous areas, and this effect is fading out as we move to areas where polygyny is more commonly practiced. The impact of PPI shocks is concentrated in rural areas where most agricultural production occurs (columns 3-7). Estimates in column (4) suggest that a standard deviation rise in PPI decreases the hazard of marriage the same year by 0.6 pp ($p<0.05$) in low polygyny areas, 0.26 pp ($p<0.1$) in medium polygyny areas and has no detectable effect in high polygyny areas.[47] There is no detectable link between PPI and the hazard of early marriage in urban areas, irrespective of whether they are located in high or low polygyny areas (columns (8) and (9)). Table A7 shows that the documented pattern is driven by food crops. There is no detectable effect of PPI for cash crops on the

[46]PPI shocks offer more cross-sectional variation for how global crop prices affect local economies. This variation provides stronger identification arguments compared to the ones from CPI. The effect of PPI is also informative of the potential impact of policy interventions that generate aggregate windfall cash income. This allows me to derive plausible policy conclusions regarding such interventions.

[47]Column (5) also shows that this pattern is concentrated among ethnic groups that practice bride price payment at marriage. Columns (6) and (7) show a similar pattern of results for the hazard of marriage before age 18: A rise in PPI increases the hazard of marriage in low and medium polygyny areas but not in high polygyny areas.

Table 3: Polygyny, Droughts, and Timing of Marriage in Sub-Saharan Africa

	(1)	(2)	(3)	(4)	(5)	(6)
	Married by:				Married by age 25	
	Age 25	Age 25	Age 21	Age 18	Bride price	No bride price
Drought	0.0075***					
	(0.0021)					
Drought x polygyny rate	-0.0137**					
	(0.0065)					
Drought x low polygyny		0.0064***	0.0057***	0.0045**	0.0078***	-0.0028
		(0.0021)	(0.0020)	(0.0020)	(0.0024)	(0.0030)
Drought x medium polygyny		0.0038**	0.0035**	0.0024	0.0036*	0.0024
		(0.0016)	(0.0017)	(0.0017)	(0.0019)	(0.0031)
Drought x high polygyny		0.0004	0.0012	0.0015	-0.0008	0.0016
		(0.0024)	(0.0025)	(0.0025)	(0.0021)	(0.0058)
Observations	2,459,177	2,459,177	2,154,271	1,702,155	1,344,360	369,241
Adjusted R-squared	0.0616	0.0616	0.0683	0.0728	0.0636	0.0645
Mean dependent variable	0.112	0.112	0.105	0.0856	0.118	0.107

All regressions include age FE, birth year FE, and grid-cell FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. Observations are at the level of person x age. The dependent variable is a dummy equal to one if the woman gets married at the age corresponding to a given observation. The average annual hazard of child marriage is 0.086, 0.112, and 0.145 in low, medium, and high polygyny areas, respectively. The full sample includes women aged 25 or older at the time of the interview. Column (3) restricts this sample to person x age observations from ages 12 to 20, and column (4) uses observations from ages 12 to 17 (child marriage). Observations with no information on the practice of bride price payment in their ethnic group are dropped in columns (5) and (6). A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. All regressions are weighted using country population-adjusted survey sampling weights.

timing of marriage, irrespective of the structure of the local markets (polygyny or not).

Table 5 includes CPI (no country × year fixed) and confirms that households and markets react in a symmetric way to aggregate shocks. The coefficients on PPI variables remain stable. CPI shocks do not affect the hazard of early marriage in rural areas (columns 1-4). For urban areas, a standard deviation rise in CPI increases the hazard of marriage the same year by 1.6 pp in low polygyny areas, 1.4 pp in medium polygyny areas and has no detectable effect (magnitude of 0.3 pp) in high polygyny areas (column (6) and (8)). The attenuation effect is less pronounced (and not statistically significant) between areas with low and medium levels of polygyny, but the overall pattern is consistent with the model's prediction.

According to the model, the attenuation effect of PPI and CPI shocks on marriage timing is due to the fact that the demand for second spouses is more sensitive to income and price changes. Table 6 tests directly the impact of PPI shocks on the market shares of young men to confirm this mechanism. It shows that women who marry during a high PPI year are 1.9 pp ($p<0.05$) more likely to marry as junior spouses as opposed to marrying as first spouses (column 3). They are also more likely to marry older men only in high polygyny areas. The results on the age gap are not statistically significant. Still, the differences in coefficient magnitude are substantial (+/-0.02 years in low/medium polygyny areas versus 0.14 years in high polygyny areas) and consistent with what the model predicts (see columns 4-6).

Table 4: Polygyny, PPI, and Timing of Marriage

	Whole Sample		Rural					Urban	
	Marriage before age 25		Marriage before age 25			Marriage before age 18		Marriage before age 25	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PPI	-0.0033***		-0.0071***			-0.0039**		0.0006	
	(0.0013)		(0.0023)			(0.0015)		(0.0014)	
PPI X polygyny rate	0.0076*		0.0157**			0.0080		-0.0030	
	(0.0045)		(0.0066)			(0.0080)		(0.0056)	
PPI × low polygyny		-0.0028***		-0.0060***			-0.0027**		0.0001
		(0.0010)		(0.0020)			(0.0011)		(0.0011)
PPI × medium polygyny		-0.0012		-0.0026*			-0.0032**		0.0010
		(0.0008)		(0.0014)			(0.0016)		(0.0012)
PPI × high polygyny		0.0005		0.0006			0.0012		-0.0018
		(0.0018)		(0.0023)			(0.0035)		(0.0022)
PPI × bride price					-0.0065***				
					(0.0015)				
PPI × no bride price					-0.0032				
					(0.0039)				
PPI × polygyny rate × bride price					0.0096*				
					(0.0049)				
PPI × polygyny rate × no bride price					0.0010				
					(0.0109)				
Observations	1,630,520	1,630,520	974,426	974,426	678,801	635,162	635,162	647,716	647,716
Adjusted R-squared	0.0625	0.0625	0.0701	0.0701	0.0714	0.0835	0.0835	0.0472	0.0472
Mean dependent variable	0.116	0.116	0.134	0.134	0.143	0.0993	0.0993	0.0884	0.0884

All regressions include age FE, birth year FE, grid-cell FE, and country × calendar year FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa (SSA). Observations are at the level of person x age. The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. The PPI is measured in terms of average temporal standard deviations. All Regressions are weighted using country population-adjusted survey sampling weights.

5.4 Threats to Identification

This section discusses the potential threats to identification that may affect the estimated effects. It shows that such threats are less likely to play an important role in my setting. Each potential threat could challenge the evidence presented in support of a specific prediction of the model, but none of them is consistent with all the three predictions taken together. They cannot offer a plausible alternative explanation for why aggregate shocks (both positive and negative) would have a strong impact on marriage timing for girls only in monogamous areas and at the same time have a strong effect on the age of the men they marry to only in polygynous areas precisely in the directions predicted by the model.

5.4.1 Potential Differential Effect of Aggregate Shocks?

The first threat to the identification is whether the aggregate shocks considered here differ in polygamous and monogamous areas. This analysis defines a drought year in a given location as a calendar year with rainfall below the 15th percentile of that location's historical distribution. It means that all locations have the same probability of experiencing a drought in any given year. By construction, this measure of rainfall shocks will be orthogonal to observable and unobserved permanent local characteristics such as the extent to which polygyny is practiced. Similarly, PPI and CPI shocks are also defined in a relative term. They are measured in terms of temporal standard deviation from their historical mean in a given location.

The second concern is whether a given shock has the same effect on household economic conditions in monogamous and polygynous areas. The global commodity price shocks affect real income for a given level of output quantity. There is no obvious reason for the value of production to be different between monogamous and polygynous areas. Rainfall shocks, however, affect agricultural production, and

Table 5: Polygyny, PPI/CPI, and Timing of Marriage

	Rural				Urban			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PPI	-0.0063***		-0.0063***		-0.0007		-0.0007	
	(0.0023)		(0.0023)		(0.0014)		(0.0014)	
PPI × polygyny rate	0.0136**		0.0137**		0.0008		0.0008	
	(0.0068)		(0.0068)		(0.0062)		(0.0062)	
CPI	0.0065		0.0064		0.0172***		0.0171***	
	(0.0054)		(0.0053)		(0.0058)		(0.0058)	
CPI × polygyny rate	0.0121		0.0122		-0.0214		-0.0213	
	(0.0103)		(0.0103)		(0.0141)		(0.0142)	
PPI × low polygyny		-0.0055***		-0.0055***		-0.0010		-0.0010
		(0.0020)		(0.0020)		(0.0009)		(0.0009)
PPI × medium polygyny		-0.0015		-0.0015		0.0004		0.0004
		(0.0011)		(0.0011)		(0.0012)		(0.0012)
PPI × high polygyny		-0.0001		-0.0000		-0.0006		-0.0006
		(0.0021)		(0.0021)		(0.0024)		(0.0024)
CPI × low polygyny		0.0080		0.0078		0.0158***		0.0158***
		(0.0053)		(0.0053)		(0.0057)		(0.0057)
CPI × medium polygyny		0.0055		0.0054		0.0141**		0.0141**
		(0.0059)		(0.0059)		(0.0063)		(0.0063)
CPI × high polygyny		0.0127*		0.0125*		0.0036		0.0036
		(0.0069)		(0.0069)		(0.0079)		(0.0079)
Observations	965,595	965,595	965,595	965,595	642,518	642,518	642,518	642,518
Adjusted R-squared	0.0679	0.0679	0.0680	0.0680	0.0439	0.0439	0.0439	0.0439
Country × time trend	NO	NO	YES	YES	NO	NO	YES	YES
Mean dependent variable	0.133	0.133	0.133	0.133	0.0880	0.0880	0.0880	0.0880

All regressions include age FE, birth year FE, grid-cell FE, and calendar year FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa (SSA). Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. The PPI and CPI are measured in terms of average temporal standard deviations. All Regressions are weighted using country population-adjusted survey sampling weights.

droughts could, in theory, lead to a bigger drop in household resources in monogamous areas compared to polygamous ones.[48] The empirical evidence suggests that this is not the case. Appendix Table A18 shows the relationship between droughts and agricultural output/economic conditions using country-level data.[49] I split the sample of countries into countries with low and high polygyny, and the results show that droughts have the same effect on household resources in both groups. They reduce the average cereal yield by 14 % in low polygyny countries versus 11% in high polygyny countries (column 2, p<0.01 for each), and these coefficients are not statistically different from each other. Similarly, they reduce household consumption by 4 % versus 8 % (column 4) and per capita GDP by 4 % versus 9 %, respectively.[50] None of these two pairs of coefficients are statistically different from each other, and their magnitudes even suggest, if anything, a potentially bigger effect of droughts on household consumption and GDP per capita in high polygyny areas. Moreover, such alternative explanations based on the idea that polygamous

[48] Akresh et al. (2012) and Damon and McCarthy (2019) argue that polygamous and monogamous households may have different production technology so they could, in theory, react differently to rainfall shocks.

[49] Dessy et al. (2021) use household level production data and also find that the extent to which polygyny is practiced in rural communes of Mali does not affect the (contemporaneous) impact of droughts on crop yield. They only find that polygyny improves farm households' capacity to recover from droughts in subsequent years in their data.

[50] Columns (1), (3), and (5) show the overall effect without any sample split following Corno et al. (2020). Their paper provides more details on the data used for this exercise.

Table 6: PPI at the Time of Union and Marriage Characteristics in Rural Areas

	Junior wife (2nd wife or higher order)			Husband age gap		
	(1)	(2)	(3)	(4)	(5)	(6)
PPI x low polygamy		0.0003			0.0222	0.0217
		(0.0029)			(0.0672)	(0.0669)
PPI x medium polygamy		0.0008			-0.0214	-0.0209
		(0.0040)			(0.0710)	(0.0710)
PPI x high polygamy		0.0111*			0.1386	0.1396
		(0.0066)			(0.1005)	(0.1007)
PPI	-0.0021		0.0192**	-0.0158		
	(0.0040)		(0.0085)	(0.0802)		
PPI x polygyny rate	0.0178			0.1701		
	(0.0156)			(0.2574)		
Age first marriage						-0.1160
						(0.1002)
Observations	108,772	108,772	33,326	110,961	110,961	110,961
Adjusted R-squared	0.0933	0.0933	0.0642	0.1438	0.1438	0.1438
Mean dependent variable	0.182	0.182	0.555	9.758	9.758	9.758

OLS regressions with observations at the individual level. Sample of married women aged 25 or older at the time of the survey living in rural areas. The dependent variables are: whether a woman married as a junior wife (columns 1-3) and the husband's age gap (columns 4-6). All regressions include birth year FE, grid-cell FE, and marriage year FE. Column (3) restricts the sample to women in polygynous unions in medium and high polygyny areas. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The PPI is measured in terms of average temporal standard deviations. All Regressions are weighted using country population-adjusted survey sampling weights.

households are more resilient to droughts cannot explain why these shocks increase the likelihood of marrying younger men only in polygynous areas. This alternative story also fails to explain the symmetric (opposite) effect of positive aggregate shocks.

5.4.2 Differential Marriage Market Size and Migration?

Differential Migration Behavior: A potential concern for identifying the documented attenuation effect is whether marriage migration happens more (or less) often during droughts and whether this occurs differentially in polygamous and monogamous areas. I focus first on the evidence regarding the impact of aggregate shocks on marriage timing. Table A14 shows that this is not the case. Columns (1) and (2) show that women who got married during droughts do not appear less likely to have remained in their village/city of birth compared to the others, and this is irrespective of the extent to which polygyny is practiced. Columns (3) and (4) also show that they are not more likely to have migrated for marriage during a drought in both monogamous and polygamous areas. Differential migration behavior during droughts is therefore not a threat to the identification strategy and cannot explain the documented pattern of empirical evidence. Table A15 shows results of the same exercise using PPI as a source of variation in aggregate income. Women living in rural areas who marry in high PPI years are slightly more likely to migrate after marriage but in both low and high polygyny areas (columns 1 and 2).[51] This means that there is no systematic pattern that would suggest that differential migration behavior during PPI shocks is a threat to the identification.

Differential Market Size: One could argue that the weaker effect of aggregate shocks on the timing of marriage in polygamous areas is due to the fact that marriage markets are broader in these areas, therefore weakening this relationship. Mbaye and Wagner (2017) conduct a large-scale survey in rural Senegal and collect information on the distance between the natal home and the current location of married women. Senegal has very high polygyny rates, and the average distance is 20 km for girls, so it still fits easily within the 50 × 50 km cell grids. Moreover, I do find a strong effect of aggregate shocks on the likelihood of marrying younger men only in high polygyny areas and on the likelihood of being a first/unique spouse as opposed to being a second spouse. This also suggests that there is no systematic attenuation bias in polygamous areas due to women marrying and moving outside the 50 × 50 km cell grids considered here.

5.5 Threats to Interpretation

There is a potential concern about attributing the documented differences in the impact of aggregate shocks across different areas to polygyny per se and not another factor that could be correlated with it. Importantly, no single factor can explain the spatial variation in the extent to which polygyny is practiced, as argued in Section 3.4.3. This variation is instead the result of a combination of many historic and slow-moving cultural factors. This allows us to test whether any given alternative factor can be driving the results. Ethnic traditions and religion are two of the main factors that strongly correlate with polygyny, and I check whether they could be driving the documented results.

5.5.1 Polygyny and Religion

There is a strong correlation between polygyny and religion, which may cast some doubt on the interpretation of the empirical evidence. Christian women are much less likely to be in polygynous unions than Muslims and Animists. It is indeed possible that households living in areas with different local norms in terms of polygyny also belong to different religious groups, and what I am capturing is just the effect of differences in religious practices. Given the substantial variation across space in the joint distribution of religion and polygyny documented in Appendix A.2.1, I can check whether this is the case.

In Table 7, I run the specification in Equation 5 and 6, splitting the sample into two: Christians and non-Christians. The first four columns use the full sample, and the other columns restrict the sample to observations that belong to an ethnic group that practices bride price payments. There are more Christians in the sample, and they tend to marry later, so there are significantly more *person* × *age* observations in this sub-sample and much fewer observations for the sub-sample of non-Christians. The pattern in the magnitude of the estimated coefficients is very similar across both groups: Droughts substantially affect the timing of marriage in monogamous areas, but this effect is fading out in areas with more polygyny.

[51] Three of the four coefficients are significant only at 10% level.

There is no detectable effect of droughts on marriage timing in high polygyny areas across both groups. The results from Table 7 therefore suggest that the impact of droughts on the timing of marriage depends on the extent to which polygyny is practiced in a given area and not on religion per se. Appendix Table A5 conducts a similar exercise with PPI and also shows the same pattern within both Christian and non-Christian samples.

Table 7: Polygyny, Droughts, and Timing of Marriage: Robustness to Religion

	Full sample				Bride price only			
	Christians		Non-Christians		Christians		Non-Christians	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Drought x low polygyny	0.0055***		0.0089		0.0062***		0.0256***	
	(0.0018)		(0.0080)		(0.0020)		(0.0081)	
Drought x medium polygyny	0.0033*		0.0032		0.0036		0.0043	
	(0.0020)		(0.0033)		(0.0024)		(0.0040)	
Drought x high polygyny	0.0011		-0.0003		-0.0043		0.0007	
	(0.0047)		(0.0033)		(0.0054)		(0.0025)	
Drought		0.0059***		0.0116**		0.0074***		0.0162***
		(0.0022)		(0.0056)		(0.0026)		(0.0063)
Drought x polygyny rate		-0.0085		-0.0232*		-0.0168		-0.0289**
		(0.0100)		(0.0128)		(0.0114)		(0.0127)
Observations	1,428,209	1,428,209	669,376	669,376	651,243	651,243	450,924	450,924
Adjusted R-squared	0.0537	0.0537	0.0707	0.0697	0.0525	0.0525	0.0778	0.0762
Mean dependent variable	0.124	0.124	0.163	0.163	0.126	0.126	0.165	0.165

All regressions include age FE, birth year FE, and grid-cell FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa. Full regression sample: women aged 25 or older at the time of interview. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. Results are weighted using population-adjusted survey sampling weights. Observations with no information on religion are dropped.

5.5.2 Polygyny and Kinship System

The kinship system in most areas across Africa is patrilineal except in the matrilineal belt that stretches across Central Africa (see Appendix Figure A5). In matrilineal kinship systems, lineage and inheritance are traced through women. This means that women have more support from their families and are less subject to the authority of their husbands. This correlates with the practice of monogamy (or less polygyny), but there is still substantial variation in the data to test whether the pattern documented in this paper is driven by kinship systems. Table 8 shows that the main results regarding the impact of droughts on the timing of unions hold in both kinship systems. The coefficients β and γ are both significant, have the expected signs and similar magnitudes when I run Equation 5 only using on one hand observations from matrilineal ethnic groups (columns (3) and (7)) and the other hand those that are not from a matrilineal ethnic group (columns (1) and (5)).[52] The results are similar when I split the drought variable into three dummies for low, medium, and high polygyny areas (other columns of Table 8). Appendix Table A6 shows that the documented pattern for PPI also holds for patrilineal ethnic groups, but the impact of PPI is noisier within the matrilineal sample.

[52]Columns 5 and 7 restrict the sample to respondents that are from an ethnic group that practices bride price payments.

These results show that the documented heterogeneity in the impact of droughts on marriage timing and other marital outcomes is not driven by kinship systems. These kinship systems are becoming less relevant for economic decision-making within households. The increasing privatization of production and consumption activities across Sub-Saharan Africa has led to more individualistic behavior within nuclear families (parents and children). This has weakened matrilineal and patrilineal influence on people's wealth transfer behaviors and other family-related decisions. Mtika and Doctor (2002) is one of the rare papers that studies financial transfers among family members across different kinship systems. Using data from rural Malawi, the authors show that most transfers happen between parents and children, and transfers outside the nuclear family are not patterned differently under matrilineality and patrilineality. In particular, even respondents of the matrilineal group receive and give more to their parents than their maternal uncles. Moreover, women give and receive fewer transfers than men, irrespective of the kinship system. This similarity in the role of parents may explain the fact that the documented heterogeneity in the impact of droughts on marriage timing is present in both kinship systems when there is a bride price payment.

Table 8: Polygyny, Droughts, and Timing of Marriage: Robustness to Kinship System

	Full sample				Bride price only			
	Not Matrilineal		Matrilineal		Not Matrilineal		Matrilineal	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Drought	0.0078***		0.0088**		0.0087***		0.0123**	
	(0.0022)		(0.0041)		(0.0023)		(0.0053)	
Drought x polygyny rate	-0.0119**		-0.0366**		-0.0143**		-0.0521**	
	(0.0059)		(0.0180)		(0.0061)		(0.0224)	
Drought x low polygyny		0.0073***		0.0043		0.0083***		0.0071*
		(0.0022)		(0.0033)		(0.0023)		(0.0041)
Drought x medium polygyny		0.0043**		0.0025		0.0043**		0.0000
		(0.0020)		(0.0027)		(0.0022)		(0.0037)
Drought x high polygyny		0.0011		-0.0155*		0.0007		-0.0189*
		(0.0019)		(0.0088)		(0.0020)		(0.0106)
Observations	1,316,604	1,316,604	396,997	396,997	1,151,269	1,151,269	193,091	193,091
Adjusted R-squared	0.0656	0.0656	0.0577	0.0577	0.0660	0.0660	0.0517	0.0518
Mean dependent variable	0.121	0.121	0.117	0.117	0.121	0.121	0.101	0.101

All regressions include age FE, birth year FE, and grid-cell FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa. Full regression sample: women aged 25 or older at the time of interview. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. Results are weighted using population-adjusted survey sampling weights. Observations with no information on the kinship system in their ethnic group are dropped.

5.6 Consequences on Female Fertility

This section investigates a direct and dramatic consequence of early marriage: female early fertility. This is one of the most critical risks facing teenage girls in developing countries (Duflo et al., 2015; Chari et al., 2017). Adolescent pregnancy is associated with increased risks of maternal and fetal complications, including premature delivery, and worse health and socioeconomic outcomes for the next generation. Pregnancy complications and childbirth are the leading causes of death for girls aged 15 to 19 in developing countries (Save the Children, 2004). Fertility is, therefore, one of the main channels through which temporary shocks such as droughts and commodity price shocks can have long-term consequences when they affect the timing of unions. I am especially interested in testing whether the documented differences in the equilibrium effect of aggregate shocks on the marriage market lead to differences in early fertility outcomes.

I study the effect of droughts on the onset of fertility, substituting marriage with birth as the outcome variable in equation 5 and 6. Columns (1) and (2) of Table 9 show that exposure to drought substantially increases the annual hazard of early fertility (for age range 12-24) in monogamous areas but only has a small impact in polygynous ones. This hazard increases by 0.4 pp in low and medium polygyny areas (columns 2, $p<0.05$) when there is a drought. This corresponds to a 4% increase in the average hazard. In high polygyny areas, this effect is almost halved (0.26 pp) and becomes statistically insignificant. The attenuation effect is less pronounced in this specification, but the estimated coefficients' magnitude still suggests that it happens to some sizable extent. This attenuation pattern becomes less clear when I focus on fertility onset before age 18.

These results might be less sharp because a drought that occurs in a given year might also affect fertility the following year, given the time lag between marriage, conception, and first birth. The estimated coefficients are more precisely estimated and consistent with the model's predictions when I look at the impact of exposure to droughts between ages 15 and 17 on the likelihood of having a child by age 18 using individual-level data.[53] Column (3) of Appendix Table A8 shows that the coefficient on drought and the one on its interaction with polygyny rate are both sizable and statistically significant at the 5% level. Column (4) confirms this substantial attenuation effect. A drought increases the likelihood of fertility onset in that age range by 2.1 pp ($p<0.001$) for low polygyny areas but only 0.49 pp for medium and 0.40 pp for high polygyny areas (and those two coefficients are not statistically different from zero). Early fertility onset often translates into an increased number of children in Sub-Saharan Africa due to the limited practice of family planning. Columns (5) and (6) of Appendix Table A8 show that exposure to a drought between ages 12 and 24 is positively related to fertility levels by age 25 in monogamous areas, and this effect is fading out in places where polygyny is more commonly practiced.

Columns 5-8 of Table 9 show that a rise in PPI in a given year decreases the hazard of fertility onset the same year in monogamous areas. This effect is substantially attenuated in areas where polygyny is more common to the extent that there is no detectable effect of PPI shocks on the timing of fertility onset in high polygyny areas.[54]

[53]Very few women have their first child before age 15 in my sample (5% versus 27% between age 15 and 17), so droughts have no detectable effect on fertility onset in that age range (see columns (1) and (2) of Appendix Table A8).

[54]The impact of PPI shocks is driven by the rural sub-sample as in the case of marriage timing.

Table 9: Polygyny, Drought/PPI, and Fertility Onset

Fertility onset window:	Before age 25		Before age 18		Before age 25		Before age 18	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Drought	0.0049***		0.0024					
	(0.0018)		(0.0015)					
Drought × polygyny rate	-0.0045		0.0005					
	(0.0051)		(0.0047)					
Drought × low polygyny		0.0040**		0.0029**				
		(0.0018)		(0.0014)				
Drought × medium polygyny		0.0041***		0.0017				
		(0.0015)		(0.0014)				
Drought × high polygyny		0.0026		0.0031*				
		(0.0018)		(0.0017)				
PPI					-0.0030***		-0.0019**	
					(0.0005)		(0.0009)	
PPI × polygyny rate					0.0105***		0.0061*	
					(0.0023)		(0.0032)	
PPI × low polygyny						-0.0021***		-0.0012*
						(0.0005)		(0.0007)
PPI × medium polygyny						-0.0003		-0.0009
						(0.0008)		(0.0009)
PPI × high polygyny						0.0015		0.0012
						(0.0011)		(0.0013)
Observations	2,752,317	2,752,317	1,827,869	1,827,869	1,809,171	1,809,171	1,072,799	1,072,799
Adjusted R-squared	0.0637	0.0637	0.0477	0.0477	0.0651	0.0651	0.0512	0.0512
Mean dependent variable	0.0992	0.0992	0.0544	0.0544	0.111	0.111	0.0576	0.0576

Hazard model with observations at *person* × *age* level. All regressions include age FE, birth year FE, and grid-cell FE. Columns 5-8 add *country* × *year* FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is a binary variable for fertility onset, coded to one if the woman had her first child at the age corresponding to the observation. The age range is between ages 12 and 24 (columns 1, 2, 5, and 6) or between ages 12 and 18 (the rest). The full sample includes women aged 25 or older at the time of the interview. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. The PPI is measured in terms of average temporal standard deviations. All Regressions are weighted using country population-adjusted survey sampling weights.

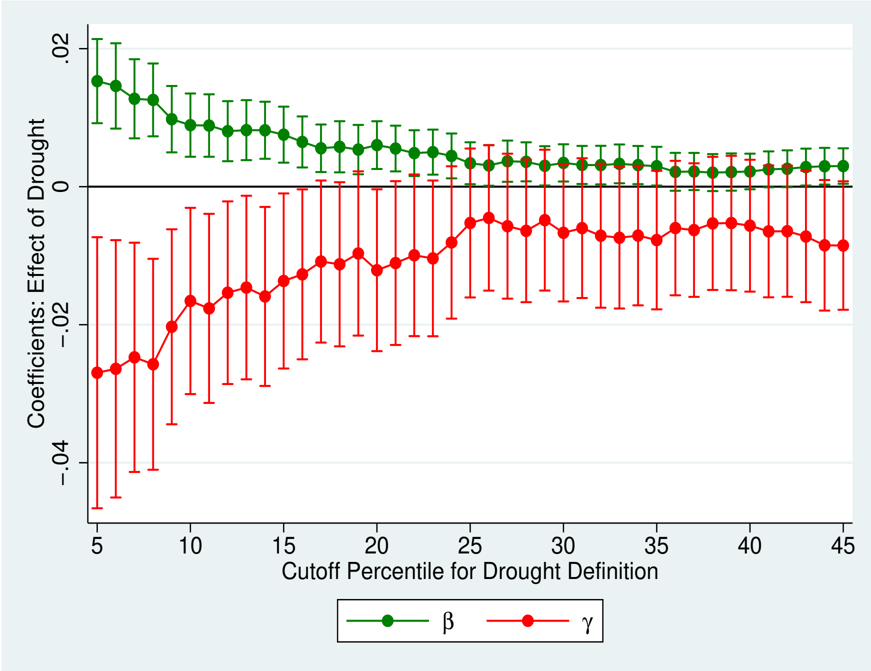
5.7 Further Robustness for Rainfall Shocks

5.7.1 Alternative Definition of Rainfall Shocks

I first check that the main results are robust to varying the cutoff used to define drought years. I re-estimate the main regression equation (Equation 5), varying the cutoff levels to define a drought from the 5th to the 45th percentile. Figure 4 shows the estimated coefficients β and γ, along with 95% confidence intervals. Point estimates are stable around the 15th percentile cutoff used in the main specification. The magnitude of both coefficients increases in absolute value as the definition of drought becomes more severe.

I also investigate the relationship between the annual rainfall levels and the hazard of early marriage. Appendix Table A19 shows that an increase in annual rainfall by 1 meter is associated with a decline in the hazard of early marriage by 1.2 percentage points in monogamous areas and has no detectable effect in high polygyny areas, only in ethnic groups that practice bride price payments (columns 1-2, $p<0.05$ for α and γ). This effect disappears completely in the absence of bride price payments (columns 3-4).

Figure 4: Robustness in the Definition of Droughts Based on Cutoffs in Rainfall Distribution



Note: The connected points show the estimated coefficients, and the capped spikes show 95% confidence intervals calculated using standard errors clustered at the grid cell level. β is the effect of droughts in the absence of polygyny. γ is the coefficient on the interaction term between droughts and polygyny rates.

5.7.2 Placebo with Past/Future Droughts and Robustness to Accounting for Times Effects in Hazard Model

I check that the documented heterogeneity is not driven by differences in the timing structure of the effect of droughts by examining lagged and future shocks. Appendix Table A21 shows that past and future shocks do not affect the timing of marriage irrespective of whether we are in areas with low, medium, or high polygyny. Only current shocks have an effect on marriage hazard in a given year in low polygyny areas (an increase of 0.6 percentage points, p<0.01) and medium polygyny areas (an increase of 0.38 percentage points, p<0.05). This is a placebo test for the identification since it shows that it is the exact and random timing of droughts that drives the results and not other alternative factors. Appendix Table A20 also indicates that the documented patterns in Table 3 are robust to accounting for time effects (calendar year fixed effects, country-specific time trends, or country × year fixed effects), which correspond to the specifications used for the PPI and CPI shocks.

5.7.3 Heterogeneity by Rural/Urban Residence and Education

Table A9 shows a heterogeneity analysis by place of residence (rural versus urban) and education. The direct effect of droughts should be concentrated in rural areas where farmers are, but agriculture plays a central role in the overall economic activity in Sub-Saharan Africa. A substantial share of the urban population is employed in the value chain of the agricultural sector (transport of crops, storage, processing, etc.) or in industries that sell goods and services to the rural economy. Significant shocks to agricultural output, such as droughts, can easily spill over and affect people that live in more urbanized areas. Moreover, polygyny is more practiced in rural areas where the main economic activity is farming (labor intensive), and the cost of living is lower than in urban areas. The value of marrying a second spouse is potentially higher in rural areas compared to urban areas, so it is essential to investigate how marital outcomes react to aggregate shocks across both places. School enrollment is also an important margin of heterogeneity to investigate. In my sample, only 50% of women have been enrolled in school. Girls that have not been enrolled in school potentially come from families that are more vulnerable to economic shocks, live in rural areas with no school around, etc.

Despite these differences, the empirical results in Table A9 show that droughts increase the hazard of early marriage in monogamous areas in both rural and urban areas (columns 1, 2, 5, and 6) and for both girls that have attended school and those that have not (columns 3,4, 7 and 8).[55] The attenuation effect (coefficient γ) due to the presence of polygyny is, however, stronger and statistically significant in rural areas (compared to urban) and for girls that have not been enrolled in school.

5.8 Other Robustness Checks

5.8.1 Independence of Shocks and long-term Polygyny Rates

The empirical strategy used in this paper relies on the assumption that the timing of aggregate shocks is orthogonal to long-term polygyny rates P_g, measured by the average share of women in union with a polygamous husband. As argued in Section 3.4, polygyny is a local norm that is at best slowly declining over time in high polygyny areas. Yearly rainfall realizations in each cell and variation in global crop prices are not likely to be correlated with the time-invariant average polygyny rates.

I pull together all the DHS survey waves in the main specification to compute the average polygyny rates. Most countries have several DHS waves with at least 5 years between two consecutive waves. As an additional confirmation that what matters is the variation in long-term polygyny rates, I check whether the main results are robust to using data from the first or the last DHS waves (10 years gap on average in between) to define polygyny rates.[56] Table A16 shows that this is the case for rainfall shocks. Column (1) uses only the first wave to define polygyny rates. It shows that droughts increase the hazard of early marriage by 0.96 percentage points ($p<0.01$) in monogamous areas ($P_g = 0$), and this effect decreases significantly in areas with higher polygyny rates (coefficient of -0.018 for interaction

[55] The spillover effect of droughts in urban areas does not seem to happen for PPI shocks. Two main reasons can explain this difference. First, droughts are production shocks that affect the quantity of agricultural output that runs through the urban economy. In contrast, PPI shocks only affect the value of each unit produced in the economy, and this does not necessarily change the wages of vulnerable urban workers involved in the agricultural value chain. Second, droughts affect all crop production levels, so they have a much higher spillover potential than PPI shocks that only affect the value of a few commodities in a given year.

[56] Ideally one would like to use historical variation in the practice of polygyny across ethnic groups to deal with this concern, but polygyny is reported among 483 of the 508 ethnic groups in the Murdock's Atlas, and there is no information on the intensity of polygyny in those societies.

term, p<0.01). This implies that droughts have no detectable impact on the timing of marriage in high polygyny rates ($P_g \sim 0.5$). Column (2) shows a similar pattern when I use only the last DHS wave to compute polygyny rates.[57] Table A17 also shows that results for PPI shocks are robust to using the first or the last DHS survey wave to compute polygyny rates.

5.8.2 Sample Restrictions Across Space

Samples with Substantial Within-Country Variation in Polygyny Norms: Figure 1 shows substantial variation in the extent to which polygyny is practiced both within and across countries. I check in this section that the main findings of this paper are robust to relying only on the countries with a substantial within-country variation. For that, I compute the interquartile range (IQR) of cell-level polygyny rates and use it to split the sample into three groups.[58] Countries with $IQR > 0.3$ have the highest level of within-country variation in polygyny rates. This sample includes the Democratic Republic of Congo, Kenya, Mozambique, and Uganda. Those with IQR between 0.2 and 0.3 have an intermediate level of variation (Cameroon, Côte d'Ivoire, Ghana, Mali, Nigeria, Sierra Leone, and Tanzania), while the others have little within-country variation. I run the main specification using the samples with substantial within-country variation (the first two samples), and the results are robust: the β coefficient is positive and significant, while the γ coefficient is negative and significant (see Table A12). Table A13 shows the same robustness for PPI shocks.

Comparing West Africa to the Rest of the Continent: As shown in Figure 1, polygyny rates are very high in West Africa compared to the rest of the sample. In most countries of this region, polygyny is the general rule with a couple of local exceptions. This is the opposite outside West Africa. In Central, Southern, and East African countries, the rule is either monogamy with few clusters of high polygyny, or grid cells with different polygyny levels seem to be evenly distributed across space (this is the case in the Democratic Republic of Congo and Tanzania, for instance). I check that my main findings are robust in all these spatial configurations in Table A10. The results show that this is the case. A substantial part of the sub-sample of women living outside West Africa do not have bride price customs, and coefficients in columns (5) and (6) are smaller and not statistically significant. The estimated coefficients have the same pattern in magnitude and significance levels across these two regions when I restrict the sample to women with bride price customs in their ethnic group as predicted by the model. I document similar patterns for PPI shocks in Table A11. This means that the impact of aggregate shocks on family formation outcomes in a given market depends on the extent to which polygyny is practiced in that market, irrespective of the spatial pattern of local norms in neighboring areas.

[57] Columns (3) and (4) split the continuous polygyny rates into terciles and show the same pattern.
[58] IQR is the difference between 75th and 25th percentiles of the cell-level polygyny rate distribution.

6 Conclusion

This paper has documented how aggregate shocks affect family formation outcomes in the presence of polygyny. In this case, the key marital outcomes for girls are the timing of marriage, the spousal age gap, and whether they marry as first/unique spouses as opposed to second spouses. Polygyny is modeled as a sequential one-to-one matching in a simple supply and demand framework where bride price acts as an important source of consumption smoothing.

The demand side of the market has two independent components: the demand for first/unique spouses from young men and the demand for second spouses from older men. I have shown that the latter component is more elastic to income and price changes in settings where polygyny is practiced even among relatively poor men (not just the rich elite). As predicted by the model, I found that droughts increase the market shares of young men that are looking for first/unique spouses at the expense of older men in the polygynous areas of Sub-Saharan Africa. Consequently, these adverse shocks have a much weaker impact on marriage timing in polygynous areas than in monogamous ones. I also tested the effects on marital outcomes of global crop price shocks that affect food-producing and food-consuming areas in opposite directions. I found that households and markets react in a symmetric way to positive and negative shocks.

In addition to improving our understanding of the complex relationship between the key marital outcomes mentioned above and how they react to changes in aggregate economic conditions, this paper has important policy implications. First, it shows that policy interventions that generate windfall aggregate income can have unintended negative consequences for marital outcomes. They increase the market shares of older men that are looking for second spouses in polygynous areas. These policies should therefore be accompanied by support measures in polygamous areas to ensure they do not deteriorate family formation outcomes by funding more second unions. This is potentially the case for fairly common policy interventions such as large-scale unconditional cash transfer programs, land titling programs, programs that improve farm-gate prices, public work programs, and infrastructure programs that boost local economic activity (roads, railways, dams, etc.). Second, aggregate income stabilization policies are more efficient/needed in monogamous areas since they can help against an increase in child marriage that will otherwise occur in these areas. The presence of polygyny creates some sort of inertia to temporary shocks for the equilibrium quantity of child marriage, making such intervention less efficient in this setting. As argued in the paper, adverse shocks can even create opportunities for young men (it makes them more likely to find a spouse) and for women (they are more likely to marry younger men as first spouses). Therefore, it is crucial to consider the marriage market structure when designing policy interventions that could impact family formation outcomes.

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Appendix

A.1 Proofs

A.1.1 Proposition 1

Part 1:

A household i wants to marry off their adult daughter (oldest generation) by the end of period t if and only if:

$$
\begin{aligned}
& U^f_{o,t}(b_t = 1 | M_{t-1} = 0, y_t, \epsilon_{it}, \tau_t) > U^f_{o,t}(b_t = 0 | M_{t-1} = 0, y_t, \epsilon_{it}) \\
\iff \quad & \frac{(y_t + \epsilon_{it} + \tau_t)^{1-\gamma}}{1-\gamma} + V^f_M > \frac{(y_t + \epsilon_{it} + w^f_o)^{1-\gamma}}{1-\gamma} + V^f_U \\
\iff \quad & \tau_t > \big[(y_t + \epsilon_{it} + w^f_o)^{1-\gamma} - (1-\gamma)\big(V^f_M - V^f_U\big)\big]^{\frac{1}{1-\gamma}} - y_t - \epsilon_{it} = \underline{\tau}_t
\end{aligned}
$$

Similarly, an unmarried old son in his household j wants to marry if:

$$
\begin{aligned}
& \frac{(y_t + \epsilon_{jt} - w^{m,l}_o + w^f_g - \tau_t)^{1-\gamma}}{1-\gamma} + V^{m,nf}_M > \frac{(y_t + \epsilon_{jt} - w^{m,l}_o)^{1-\gamma}}{1-\gamma} + V^{m,nf}_U \\
\iff \quad & \tau_t < y_t + \epsilon_{jt} - w^{m,l}_o + w^f_g - \big[(y_t + \epsilon_{jt} - w^{m,l}_o)^{1-\gamma} - (1-\gamma)\big(V^{m,nf}_M - V^{m,nf}_U\big)\big]^{\frac{1}{1-\gamma}} = \bar{\tau}_t
\end{aligned}
$$

For $V^{m,nf}_M - V^{m,nf}_U \geq 0$ and $V^f_M - V^f_U \geq 0$, I have $\bar{\tau}_t \geq \underline{\tau}_t$. Any bride price $\tau^*_t \in [\underline{\tau}_t, \bar{\tau}_t]$ is an equilibrium price that makes all the old agents want to marry at t (QED).

Part 2:

An old son who is looking for a second spouse will find it optimal to second-marry if:

$$
H_2(y_t, \epsilon_{jt}, \tau_t) \equiv \Big[u\big(y_t + \epsilon_{jt} - w^{m,h}_o - \tau_t + (w^f_o + w^f_y)\big) + V^{m,nf}_{M2}\Big] - \Big[u(y_t + \epsilon_{jt} - w^{m,h}_o + w^f_o) + V^{m,nf}_M\Big] > 0
$$

Convavity and monotonicity ensures that the difference in flow utility is strictly increasing in ϵ_{jt} ($\tau_t > w^f_g$). Therefore $\epsilon^*_{m,2}$ is defined such that $H_2(y_t, \epsilon^*_m, \tau_t) \equiv 0$ (QED).

Note: $\epsilon^*_{m,2}$ is a decreasing function of $V^{m,nf}_{M2} - V^{m,nf}_M$. This will play a crucial role in the proofs of Proposition 4 and 5.

A.1.2 Proposition 2

Define $\Omega^f = \delta\Big[E[\bar{V}^f_{o,t+1}(M_t = 0)] - E[\bar{V}^f_{o,t+1}(M_t = 1)]\Big]$: Option value of marriage for woman's family and $\Omega^m = \delta\Big[E[\bar{V}^m_{o,t+1}(M_t = 0)] - E[\bar{V}^m_{o,t+1}(M_t = 1)]\Big]$: Option value of marriage for man's family (household head). Everyone finds it optimal to marry by the end of the next period (before leaving the market), so future utility terms beyond phase 2 cancel out. The presence of a potential second spouse next period does not affect the future stream of utility expected by a man's parents at t. Their son will emancipate, and his decision to marry a second spouse does not affect his contribution to his parents' consumption in the future (as argued in Section 2).

$$\Omega^f = \delta \sum_{z\in\{H,L\}} \frac{1}{2} \int \left[u\left(y^z_{t+1} + \epsilon_{i,t+1} + \tau^*_{t+1}\right) - u\left(y^z_{t+1} + \epsilon_{i,t+1}\right)\right] dF(\epsilon_{i,t+1}) > 0$$

$$\Omega^m = \textstyle\sum_{z\in\{H,L\}} \frac{\delta}{2} \int \left[u\left(y^z_{t+1} + \epsilon_{j,t+1} + w^{m,l}_o\right) - u\left(y^z_{t+1} + \epsilon_{j,t+1} + w^{m,h}_o\right)\right] dF(\epsilon_{j,t+1}) < 0.$$

A woman's family will want her to marry young at period t if and only if:

$$W(y_t, \epsilon_{it}, \tau_t) \equiv u(y_t + \epsilon_{it} + \tau_t) - u(y_t + \epsilon_{it} + w^f_y) - \Omega^f > 0 \tag{A1}$$

Concavity and monotonicity of the utility function ensure that the right-hand side (RHS) of this equation is decreasing in ϵ_{it}, while Ω^f does not depend on it. Therefore ϵ^*_f is defined such that $W(y_t, \epsilon^*_f, \tau_t) \equiv 0$.

Similarly, a son's family will want to marry him off if:

$$H(y_t, \epsilon_{jt}, \tau_t) \equiv u(y_t + \epsilon_{jt} + w^m_y - \tau_t + w^f_y) - u(y_t + \epsilon_{jt} + w^m_y) - \Omega^m > 0 \tag{A2}$$

Again, concavity and monotonicity ensure that the RHS is strictly increasing in ϵ_{jt}, while Ω^f does not depend on it. Therefore ϵ^*_m is defined such that $H(y_t, \epsilon^*_m, \tau_t) \equiv 0$.

A.1.3 Proposition 3

Given the threshold rules and the equilibrium matching pattern defined above, the demand for child brides comes from three separate components:

- The demand for child brides as unique spouses from old unmarried sons: $D^{(1,old)}(\tau_{t-1}, y_{t-1}) = \frac{1}{1+a}\left[F(\epsilon^*_m(\tau^*_{t-1}, y_{t-1})) - (1 - F(\epsilon^*_f(\tau^*_{t-1}, y_{t-1}))\right]$. This represents the difference between the number of old men that could not get married young at $t-1$ and the number of old women that did not have to be married off as child brides at $t-1$. It is independent of y_t and τ_t. All the old unmarried women will marry old unmarried men as unique spouses. The surplus of old unmarried men will have to marry young brides. Same for old men that already have a spouse and are looking for a second one.
- The demand for child brides as first/unique spouses from potential young grooms: $D^{(1,young)}(\tau_t, y_t) = 1 - F(\epsilon^*_m(\tau_t, y_t))$. This represents young sons whose families got idiosyncratic shocks $\epsilon_{jt} > \epsilon^*_m$.
- The demand for second spouses from old grooms: $D^{(2,old)}(\tau_t, y_t, \tau_{t-1}, y_{t-1}) = \frac{p}{(1+a)}\Big[\big(1-F(\epsilon^*_m(\tau_{t-1}, y_{t-1})\big)\times \big(1 - F(\epsilon^*_{m,2}(\tau_t, y_t))\big)\Big]$. This is the joint likelihood of marrying at $t-1$ and t. Idiosyncratic income

shocks are i.i.d across time. p is the share of men that remain on the market after their first marriage (when young): $p = 0$ in case of monogamy. p is an exogenously given local norm.

The supply for young brides at t is: $S(\tau_t, y_t) = F(\epsilon_f^*(\tau_t, y_t))$.

By the Implicit Function Theorem (IFT), the chain rule, the fact that F is strictly increasing, and the fact that $D^{(1,old)}$ is independent of y_t and ϵ_t, we have:

$$\frac{\partial S(\tau_t, y_t)}{\partial y_t} = S_y(\tau_t, y_t) = f(\epsilon_f^*(\tau_t, y_t)) \frac{\partial \epsilon_f^*(\tau_t, y_t)}{\partial y_t} = -f(\epsilon_f^*(\tau_t, y_t)) \frac{\partial W/\partial y_t}{\partial W/\partial \epsilon_f^*} = -f(\epsilon_f^*(\tau_t, y_t)) < 0$$

$$\begin{aligned}
\frac{\partial D(\tau_t, y_t)}{\partial y_t} &= D_y(\tau_t, y_t) = D_y^{(1,young)}(\tau_t, y_t) + D_y^{(2,old)}(\tau_t, y_t, \tau_{t-1}, y_{t-1}) \\
= \quad & -f(\epsilon_m^*(\tau_t, y_t)) \frac{\partial \epsilon_m^*(\tau_t, y_t)}{\partial y_t} - f(\epsilon_{m,2}^*(\tau_t, y_t)) \frac{\partial \epsilon_{m,2}^*(\tau_t, y_t)}{\partial y_t} \times \frac{p}{(1+a)} \Big[1 - F(\epsilon_m^*(\tau_{t-1}, y_{t-1})\Big] \\
= \quad & f(\epsilon_m^*(\tau_t, y_t)) \frac{\partial H/\partial y_t}{\partial H/\partial \epsilon_m^*} + f(\epsilon_{m,2}^*(\tau_t, y_t)) \frac{\partial H_2/\partial y_t}{\partial H_2/\partial \epsilon_{m,2}^*} \times \frac{p}{(1+a)} \Big[1 - F(\epsilon_m^*(\tau_{t-1}, y_{t-1})\Big] \\
= \quad & f(\epsilon_m^*(\tau_t, y_t)) + f(\epsilon_{m,2}^*(\tau_t, y_t)) \times \frac{p}{(1+a)} \Big[1 - F(\epsilon_m^*(\tau_{t-1}, y_{t-1})\Big] > 0
\end{aligned}$$

With similar arguments, we also have:

$$\frac{\partial S(\tau_t, y_t)}{\partial \tau_t} = S_\tau(\tau_t, y_t) = f(\epsilon_f^*(\tau_t, y_t)) \frac{\partial \epsilon_f^*(\tau_t, y_t)}{\partial \tau_t} = -f(\epsilon_f^*(\tau_t, y_t)) \frac{\partial W/\partial \tau_t}{\partial W/\partial \epsilon_f^*} > 0$$

The denominator is negative because of the concavity and monotonicity of u and the numerator is positive because u is increasing.

$$\begin{aligned}
\frac{\partial D(\tau_t, y_t)}{\partial \tau_t} &= D_\tau(\tau_t, y_t) = D_\tau^{(1,young)}(\tau_t, y_t) + D_\tau^{(2,old)}(\tau_t, y_t, \tau_{t-1}, y_{t-1}) \\
= \quad & -f(\epsilon_m^*(\tau_t, y_t)) \frac{\partial \epsilon_m^*(\tau_t, y_t)}{\partial \tau_t} - f(\epsilon_{m,2}^*(\tau_t, y_t)) \frac{\partial \epsilon_{m,2}^*(\tau_t, y_t)}{\partial \tau_t} \times \frac{p}{(1+a)} \Big[1 - F(\epsilon_m^*(\tau_{t-1}, y_{t-1})\Big] \\
= \quad & f(\epsilon_m^*(\tau_t, y_t)) \frac{\partial H/\partial \tau_t}{\partial H/\partial \epsilon_m^*} + f(\epsilon_{m,2}^*(\tau_t, y_t)) \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial \epsilon_{m,2}^*} \times \frac{p}{(1+a)} \Big[1 - F(\epsilon_m^*(\tau_{t-1}, y_{t-1})\Big] < 0
\end{aligned}$$

A.1.4 Proposition 4

We need to compare $\frac{\partial H/\partial \tau_t}{\partial H/\partial y_t}$ and $\frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t}$. Let's consider $A_{1,2} = \frac{\partial H/\partial \tau_t}{\partial H/\partial y_t} - \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t}$.

$$
\begin{aligned}
A_{1,2} &= \frac{\partial H/\partial \tau_t}{\partial H/\partial \epsilon^*_m} - \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial \epsilon^*_{m,2}} = \frac{-u'(y_t+\epsilon^*_m+w^m_y-\tau_t+w^f_y)}{u'(y_t+\epsilon^*_m+w^m_y-\tau_t+w^f_y)-u'(y_t+\epsilon^*_m+w^m_y)} \\
&- \frac{-u'(y_t+\epsilon^*_{m,2}-w^{m,h}_o-\tau_t+(w^f_o+w^f_y))}{u'(y_t+\epsilon^*_{m,2}-w^{m,h}_o-\tau_t+(w^f_o+w^f_y))-u'(y_t+\epsilon^*_{m,2}-w^{m,h}_o+w^f_o)} \\
&= -\frac{1}{1-B_1}+\frac{1}{1-B_2} = \frac{B_2-B_1}{(1-B_1)(1-B_2)}.
\end{aligned}
$$

We have $0 < B_1 = \frac{u'(y_t+\epsilon^*_m+w^m_y)}{u'(y_t+\epsilon^*_m+w^m_y-\tau_t+w^f_y)} < 1$ and $0 < B_2 = \frac{u'(y_t+\epsilon^*_{m,2}-w^{m,h}_o+w^f_o)}{u'(y_t+\epsilon^*_{m,2}-w^{m,h}_o-\tau_t+(w^f_o+w^f_y))} < 1$

$$
B_1 = \Big(\frac{y_t+\epsilon^*_m+w^m_y-\tau_t+w^f_y}{y_t+\epsilon^*_m+w^m_y}\Big)^\gamma = \Big(1-\frac{\tau_t-w^f_y}{y_t+\epsilon^*_m+w^m_y}\Big)^\gamma
$$

$$
B_2 = \Big(\frac{y_t+\epsilon^*_{m,2}-w^{m,h}_o-\tau_t+w^f_y+w^f_o}{y_t+\epsilon^*_{m,2}-w^{m,h}_o+w^f_o}\Big)^\gamma = \Big(1-\frac{\tau_t-w^f_y}{y_t+\epsilon^*_{m,2}-w^{m,h}_o+w^f_o}\Big)^\gamma
$$

$A_{1,2} < 0 \iff B2 < B1$: This is the case if $\epsilon^*_{m,2}$ is low enough. As noted earlier in Appendix A.1.1, $\epsilon^*_{m,2}$ is a decreasing function of $V^{m,nf}_{M2} - V^{m,nf}_{M}$ so this will happen if the extra utility that men derive from having a second spouse ($V^{m,nf}_{M2} - V^{m,nf}_{M}$) is high enough.

A.1.5 Proposition 5

The equilibrium quantity of child marriage is given by $Q^*(y_t) \equiv D(y_t, \tau^*_t) = S(y_t, \tau^*_t)$.

We have: $\frac{dQ^*(y_t)}{dy_t} = S_y(y_t,\tau^*_t) + S_\tau(y_t,\tau^*_t)\frac{\partial \tau^*_t}{\partial y_t}$.

The equilibrium price is defined implicitly as solution to $S(y_t,\tau^*_t) - D(y_t,\tau^*_t) = 0$

By the Implicit Function Theorem (IFT): $\frac{d\tau^*_t}{dy_t} = -\frac{S_y-D_y}{S_\tau-D_\tau}$

So $\frac{dQ^*(y_t)}{dy_t} = S_y - S_\tau\frac{S_y-D_y}{S_\tau-D_\tau} = \Big(\frac{S_y}{S_\tau}-\frac{D_y}{D_\tau}\Big)\frac{S_\tau D_\tau}{D_\tau-S_\tau}$

Part 1: For $p = 0$ (monogamy): $\frac{dQ^*(y_t)}{dy_t} < 0$

$$
sgn\Big(\frac{dQ^*(y_t)}{dy_t}\Big) = sgn\Big(\frac{S_y}{S_\tau}-\frac{D_y}{D_\tau}\Big) = sgn\Big(\frac{\partial W/\partial y_t}{\partial W/\partial \tau_t}-\frac{\partial H/\partial y_t}{\partial H/\partial \tau_t}\Big) < 0? \qquad \text{(A3)}
$$

$$\frac{S_y}{S_\tau} - \frac{D_y}{D_\tau} = \frac{u'(y_t + \epsilon_f^* + \tau_t) - u'(y_t + \epsilon_f^* + w_y^f)}{u'(y_t + \epsilon_f^* + w_y^f + (\tau_t - w_y^f))} + \frac{u'(y_t + \epsilon_m^* + w_y^m - \tau_t + w_y^f) - u'(y_t + \epsilon_m^* + w_y^m)}{u'(y_t + \epsilon_m^* + w_y^m - (\tau_t - w_y^f))}$$
$$= 2 - \left(1 + \frac{\tau_t - w_y^f}{y_t + \epsilon_f^* + w_y^f}\right)^\gamma - \left(1 - \frac{\tau_t - w_y^f}{y_t + \epsilon_m^* + w_y^m}\right)^\gamma$$

Bernoulli inequality: $((1+x)^r \geq 1 + rx \quad \forall r \geq 1, x \geq -1)$

$$\frac{S_y}{S_\tau} - \frac{D_y}{D_\tau} \leq \gamma(\tau_t - w_y^f)\Big(\frac{1}{y_t + \epsilon_m^* + w_y^m} - \frac{1}{y_t + \epsilon_f^* + w_y^f}\Big)$$

Since $\tau_t > w_y^f$, the upper bound < 0 if $\epsilon_m^* + w_y^m > \epsilon_f^* + w_y^f$.

As long as $w_o^{m,l}$ sufficiently large (compared to $\Delta w = w_o^{m,h} - w_o^{m,l}$) , concavity ensures that $|\Omega^m| < |\Omega^f|$ and that $\epsilon_m^* > \epsilon_f^*$ as noted before.

Part 2: The negative effect of income shock on child marriage is decreasing with p

$$\frac{dQ_y^*}{dp} = -S_\tau \frac{-\frac{dD_y}{dp}(S_\tau - D_\tau) + \frac{dD_\tau}{dp}(S_y - D_y)}{(S_\tau - D_\tau)^2} > 0?$$

$$A = -\frac{dD_y}{dp}(S_\tau - D_\tau) + \frac{dD_\tau}{dp}(S_y - D_y) < 0?$$

$$\frac{dD_\tau}{dp} = f(\epsilon_{m,2}^*(\tau_t, y_t)) \times \frac{1}{(1+a)}[1 - F(\epsilon_m^*(\tau_{t-1}^*, y_{t-1})] \times \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t} < 0$$

$$\frac{dD_y}{dp} = f(\epsilon_{m,2}^*(\tau_t, y_t)) \times \frac{1}{(1+a)}[1 - F(\epsilon_m^*(\tau_{t-1}^*, y_{t-1})] > 0$$

$$\frac{dD_\tau}{dp} = \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t} \times \frac{dD_y}{dp}$$

$$A = -\frac{dD_y}{dp}\Big[-f(\epsilon_f^*(\tau_t, y_t))\frac{\partial W/\partial \tau_t}{\partial W/\partial y_t} - \Big(f(\epsilon_m^*(\tau_t, y_t))\frac{\partial H/\partial \tau_t}{\partial H/\partial y_t} + p \times \frac{dD_\tau}{dp}\Big)\Big]$$

$$+\frac{dD_\tau}{dp}\Big[-f(\epsilon_f^*(\tau_t, y_t)) - \Big(f(\epsilon_m^*(\tau_t, y_t)) + p \times \frac{dD_y}{dp}\Big)\Big]$$

$$=\frac{dD_y}{dp}\Big[f(\epsilon_f^*(\tau_t, y_t))\frac{\partial W/\partial \tau_t}{\partial W/\partial y_t} + \Big(f(\epsilon_m^*(\tau_t, y_t))\frac{\partial H/\partial \tau_t}{\partial H/\partial y_t} + p \times \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t} \times \frac{dD_y}{dp}\Big)\Big]$$

$$-\frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t} \times \frac{dD_y}{dp}\Big[f(\epsilon_f^*(\tau_t, y_t)) + \Big(f(\epsilon_m^*(\tau_t, y_t)) + p \times \frac{dD_y}{dp}\Big)\Big]$$

$$=\frac{dD_y}{dp}\Big[f(\epsilon_f^*(\tau_t, y_t))\Big(\frac{\partial W/\partial \tau_t}{\partial W/\partial y_t} - \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t}\Big) + f(\epsilon_m^*(\tau_t, y_t))\Big(\frac{\partial H/\partial \tau_t}{\partial H/\partial y_t} - \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t}\Big)\Big]$$

$$A_1 = \frac{\partial W/\partial \tau_t}{\partial W/\partial y_t} - \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t} = \Big(\frac{\partial W/\partial \tau_t}{\partial W/\partial y_t} - \frac{\partial H/\partial \tau_t}{\partial H/\partial y_t}\Big) + \Big(\frac{\partial H/\partial \tau_t}{\partial H/\partial y_t} - \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t}\Big)$$

$A_{1,1} = \frac{\partial W/\partial \tau_t}{\partial W/\partial y_t} - \frac{\partial H/\partial \tau_t}{\partial H/\partial y_t} > 0$ from Equation A3, and independent of $V_{M2}^{m,nf} - V_{M}^{m,nf}$

From Proposition 4, we have:

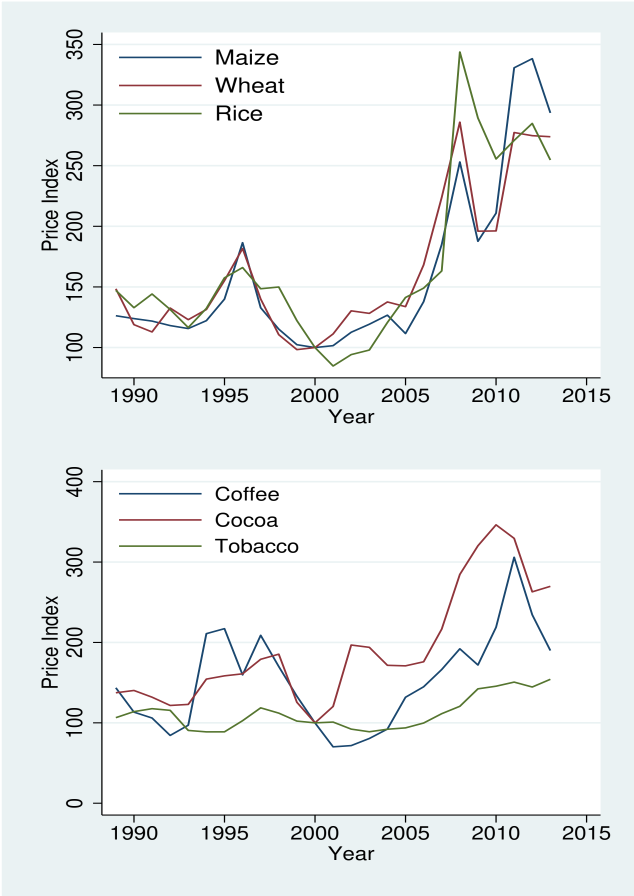
$$A_{1,2} = \Big(\frac{\partial H/\partial \tau_t}{\partial H/\partial y_t} - \frac{\partial H_2/\partial \tau_t}{\partial H_2/\partial y_t}\Big) < 0$$

Moreover, since $A_{1,2}$ is an increasing function of $\epsilon_{m,2}^*$ and $A_{1,1}$ is independent of $\epsilon_{m,2}^*$, we have $A_1 < 0$ for $\epsilon_{m,2}^*$ low enough. So $A < 0 \implies \frac{dQ_y^*}{dp} > 0$.

This means that a negative aggregate income shock increases child marriage to a lesser extent in areas with high polygyny rates compared to areas with low polygyny rates.

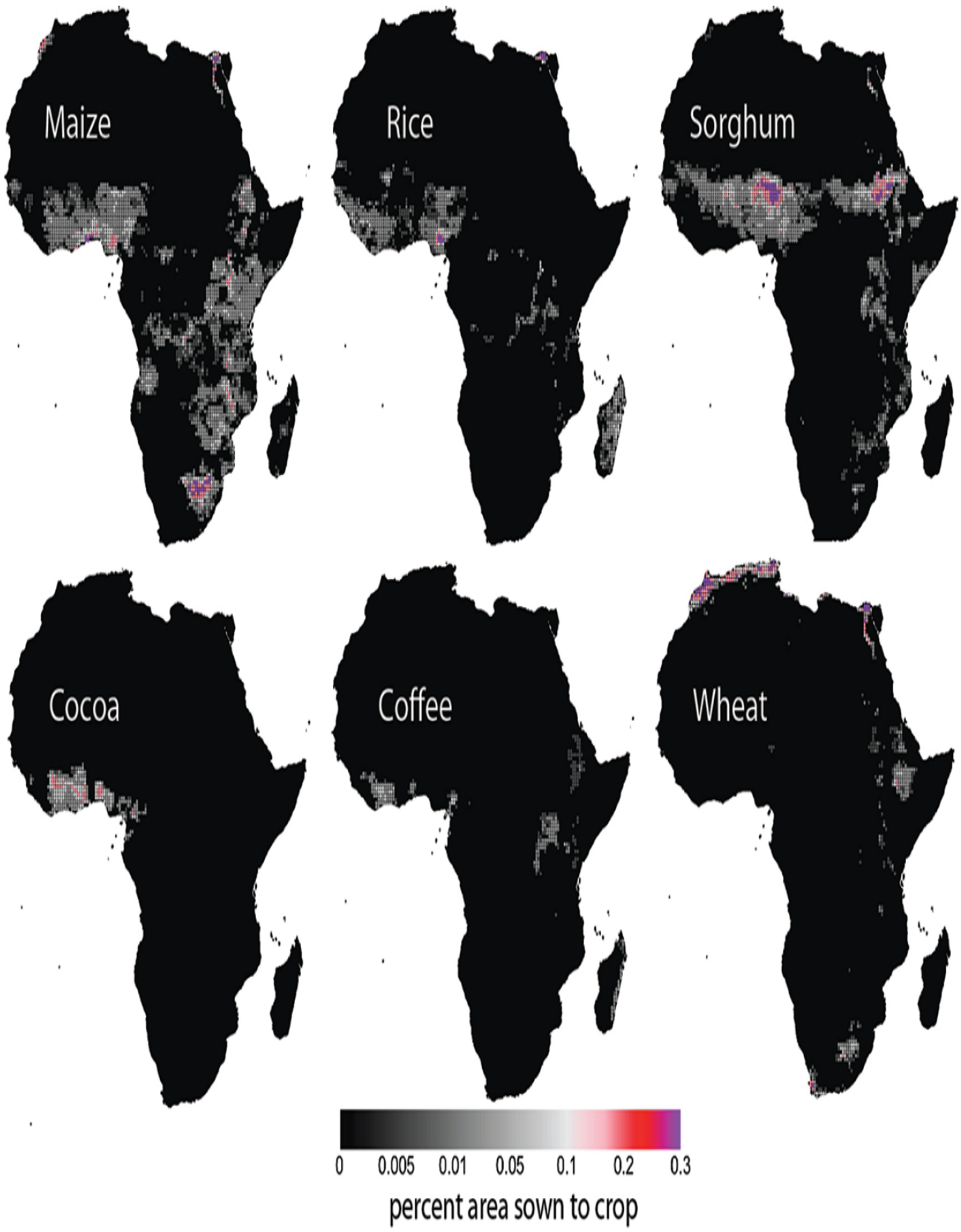
A.2 Descriptive Evidence

Figure A1: Fluctuations in Global Crop Price



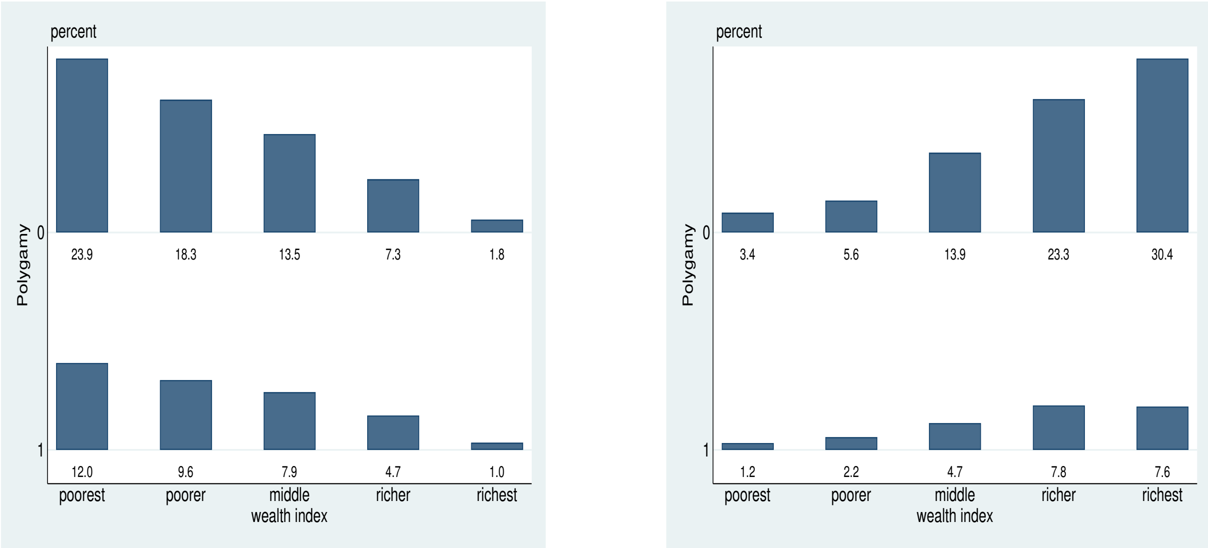
Note: Price data are taken from IMF and World Bank sources with 2000 as the base year (index=100) following McGuirk and Burke (2020).

Figure A2: Geographic Distribution of Crops in Year 2000



Source: McGuirk and Burke (2020)

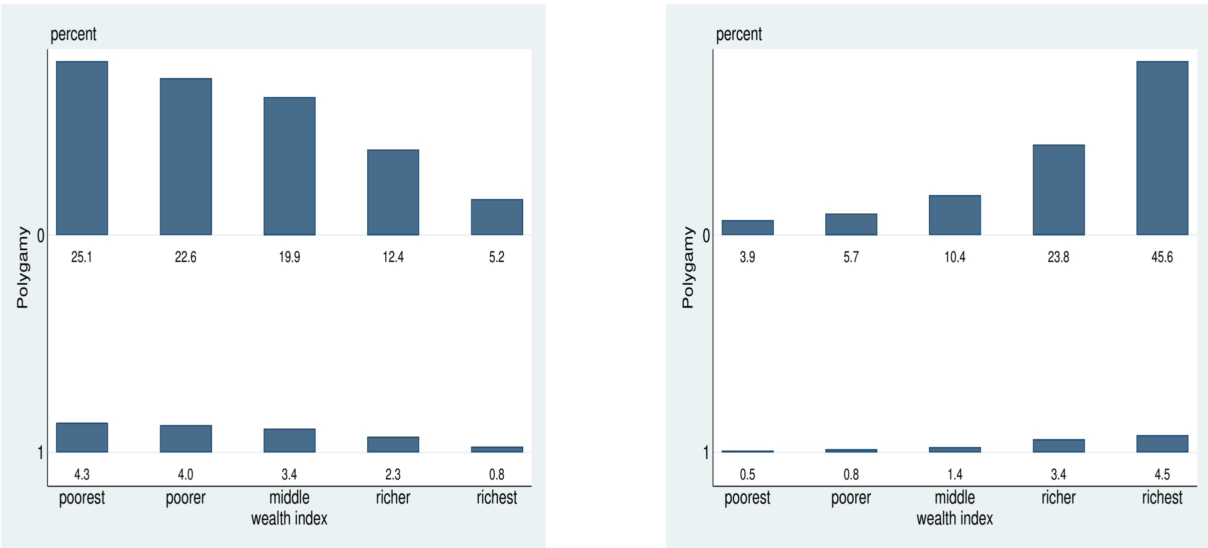
Figure A3: Polygamy by Household Wealth Quintiles in High Polygyny Areas



(a) Rural (b) Urban

Notes: Percentage of polygamous and monogamous households by wealth quintiles (joint distribution).

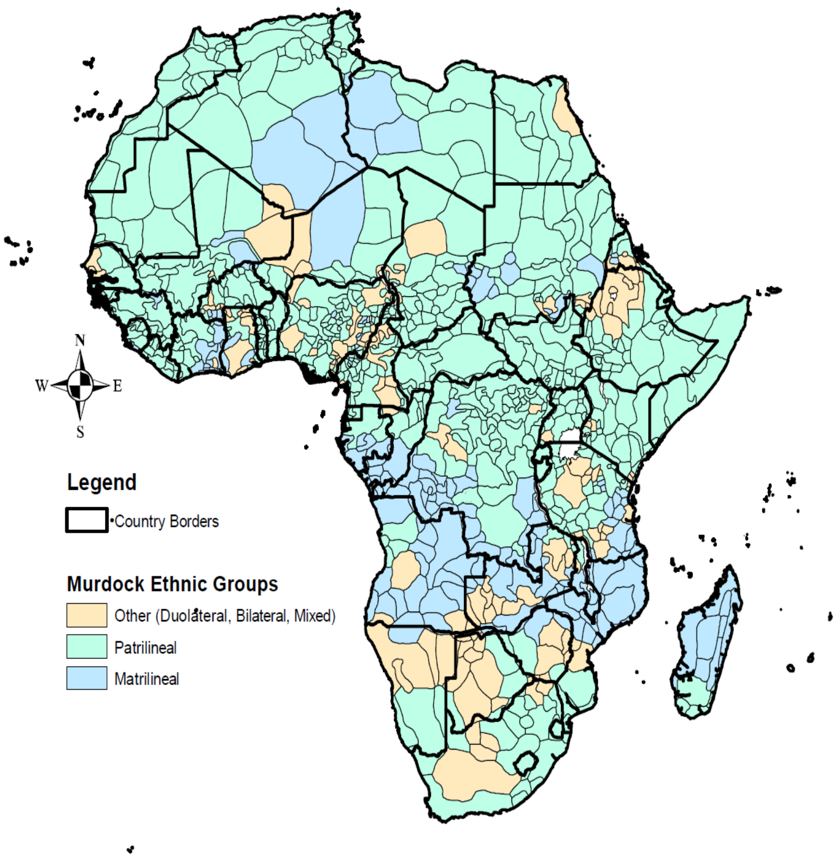
Figure A4: Polygamy by Household Wealth Quintiles in Midium Polygyny Areas



(a) Rural (b) Urban

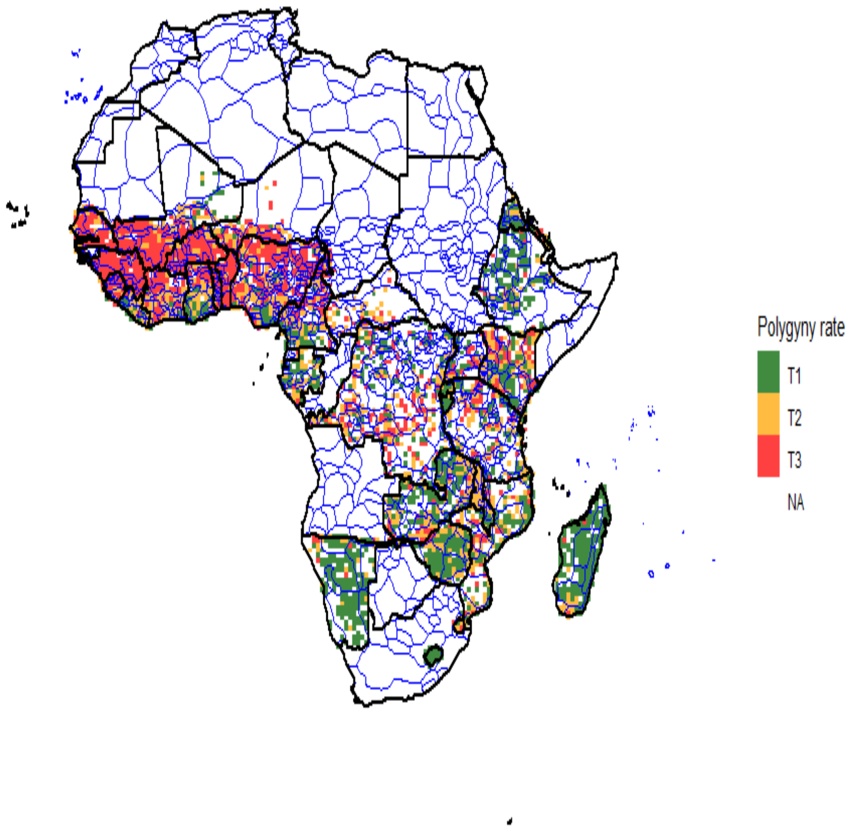
Notes: Percentage of polygamous and monogamous households by wealth quintiles (joint distribution).

Figure A5: Ethnic Group Boundaries and Kinship System in Africa



Source: Lowes (2017)

Figure A6: Practice of Polygyny across Space with Ethnic Homelands



Note: Polygyny rate is the share of women aged 25 and older that are in union with a polygynous male in each 0.5 × 0.5 decimal degree (∼ 50×50 km) weather grid cell using DHS data. T1 represents grid cells with low polygyny (less than 16%), T2 is for areas with medium polygyny (between 16 and 40%), and T3 is for areas with high polygyny (more than 40%). Blue lines are ethnic homeland boundaries.

A.2.1 Polygyny and Religion across Space

An important determinant of local norms in terms of polygyny is religion. Religious beliefs often determine social norms and are often intertwined with ethnic/traditional values in Sub-Saharan Africa. For instance, the Catholic church prohibits polygyny, while Islam tolerates or even encourages it. Some traditional African beliefs also promote polygyny, while others don't. To separate any effects coming from the differences in religious/ethnoreligious beliefs from the effect of polygyny as a local norm, I need to check that there is enough variation in the joint distribution of these two factors in the data.

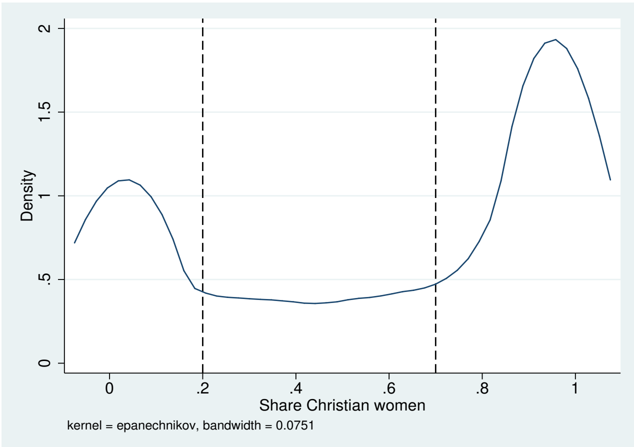
Figure A7 shows the distribution of geographical cell grids by the proportion of Christians among women aged 25 and older.[59] The distribution is bi-modal, with, on the

[59]Figure A9a and A9b show the kernel density estimation of the proportion of Muslims and traditional/other religious groups, respectively.

one hand, cells with a low share of Christians, among which 367 cells out of the 3,201 have no Christians. On the other hand, more cells have high shares of Christians. Over 490 cells have a proportion of Christians of 100%. For simplification purposes, I also split the continuous proportion of Christians into three groups and plotted the spatial distribution of cell grids by religion.

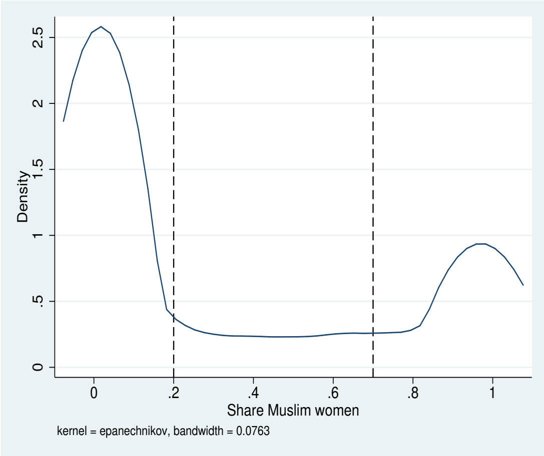
Figure A8 shows that religion is distributed in a very clustered way across space. There is some variation within most countries, but in a very contiguous way across the three levels of Christianity. Compared to the distribution of polygyny across space, there are substantial variations despite the strong spatial correlation. Many regions are homogeneous with respect to religion but have grid cells with low, medium, and high polygyny rates within. A country such as Eswatini (Swaziland) has a very high share of Christians in each cell grid of its territory and yet medium to high polygyny rates in most of them.[60]

Figure A7: Share of Christians by Geographic Grid-Cells in Sub-Saharan Africa

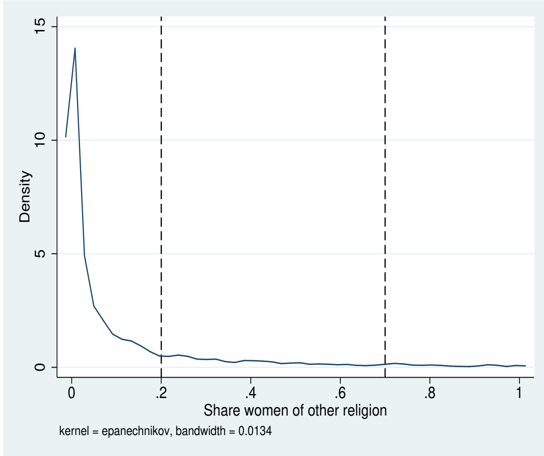


[60]Polygyny is strongly encouraged in traditional Swazi society. The current Christian king of Eswatini, Mswati III has 15 wives.

Figure A9: Distribution of the Share of non-Christian Population in Geographic Grid-Cells

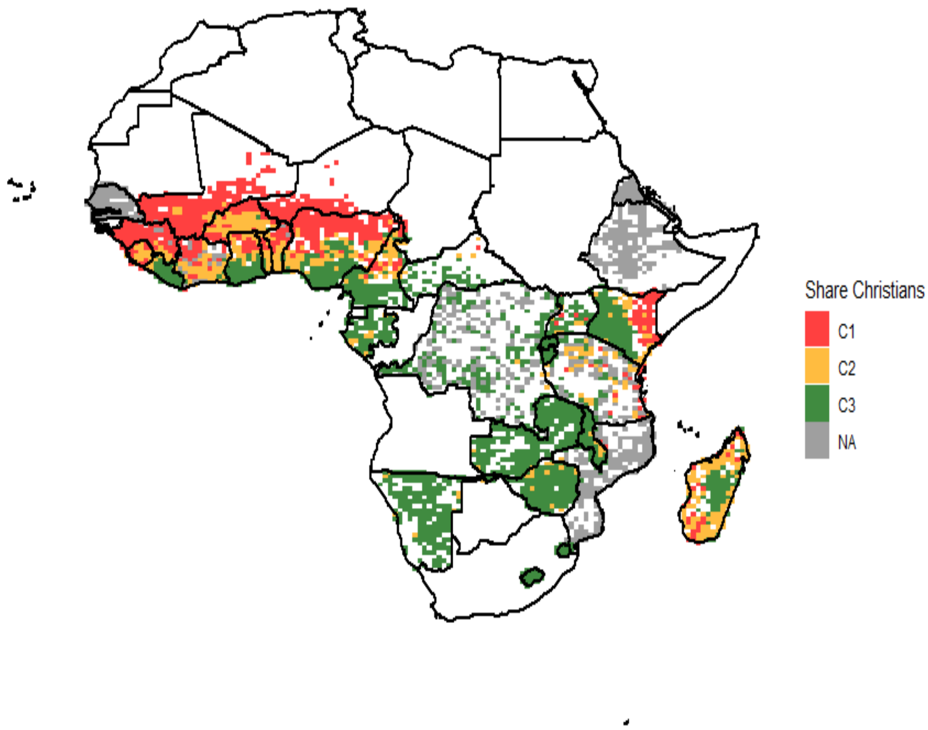


(a) Islam



(b) Other Religions

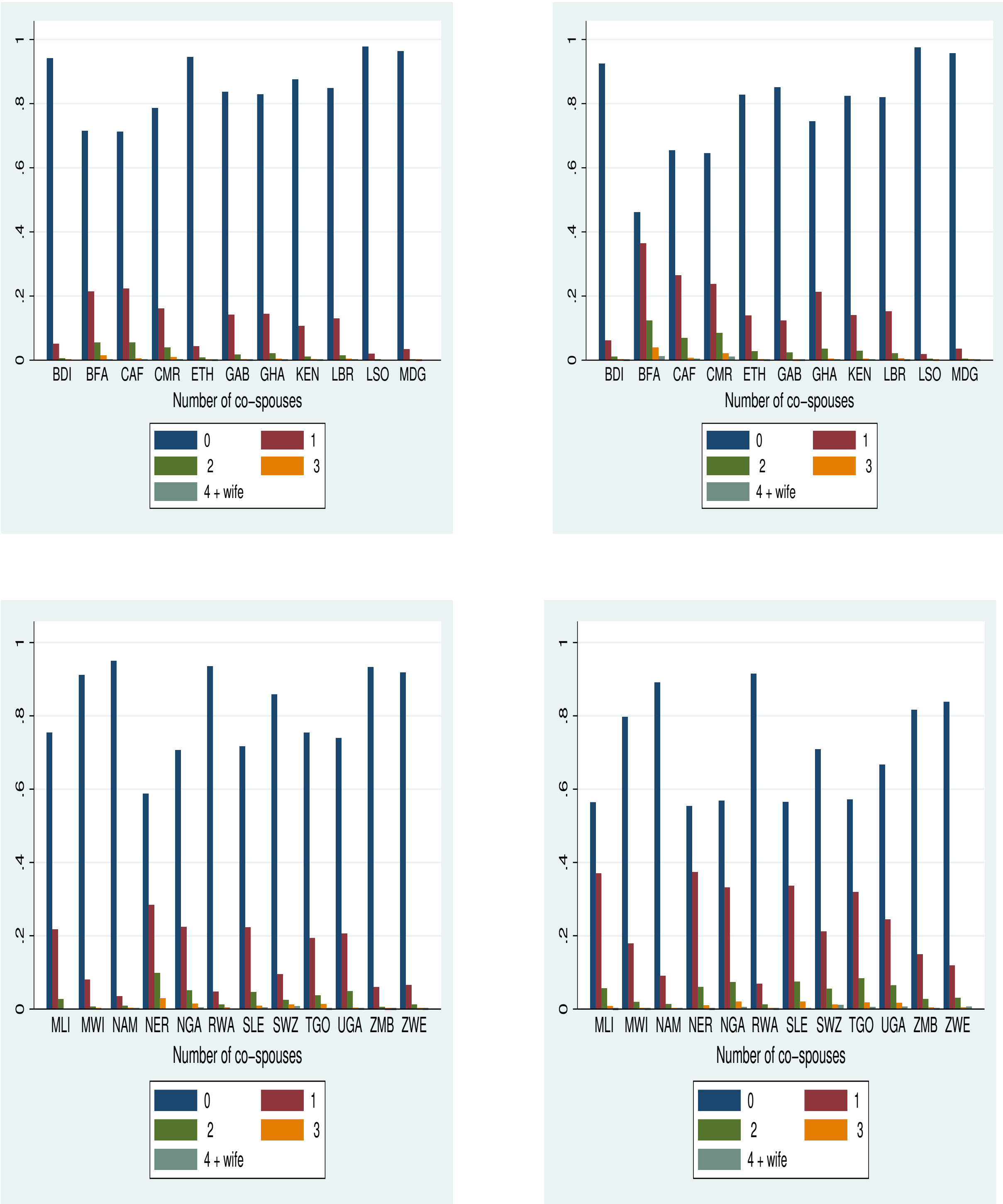
Figure A8: Proportion of Christians across Space in Sub-Saharan Africa



Note: This graph plots the proportion of women aged 25 and older that are Christians in each 0.5 × 0.5 decimal degree weather grid cell. C1 represents grid cells with a low proportion of Christians (less than 20%), C2 is for areas with a medium proportion (between 20 and 70%), and C3 is for areas with a high proportion of Christians (more than 70%). Grid-cells in grey are cells that appear in DHS survey waves in which there is no information on religion.

A.2.2 Country Level Descriptive Evidence

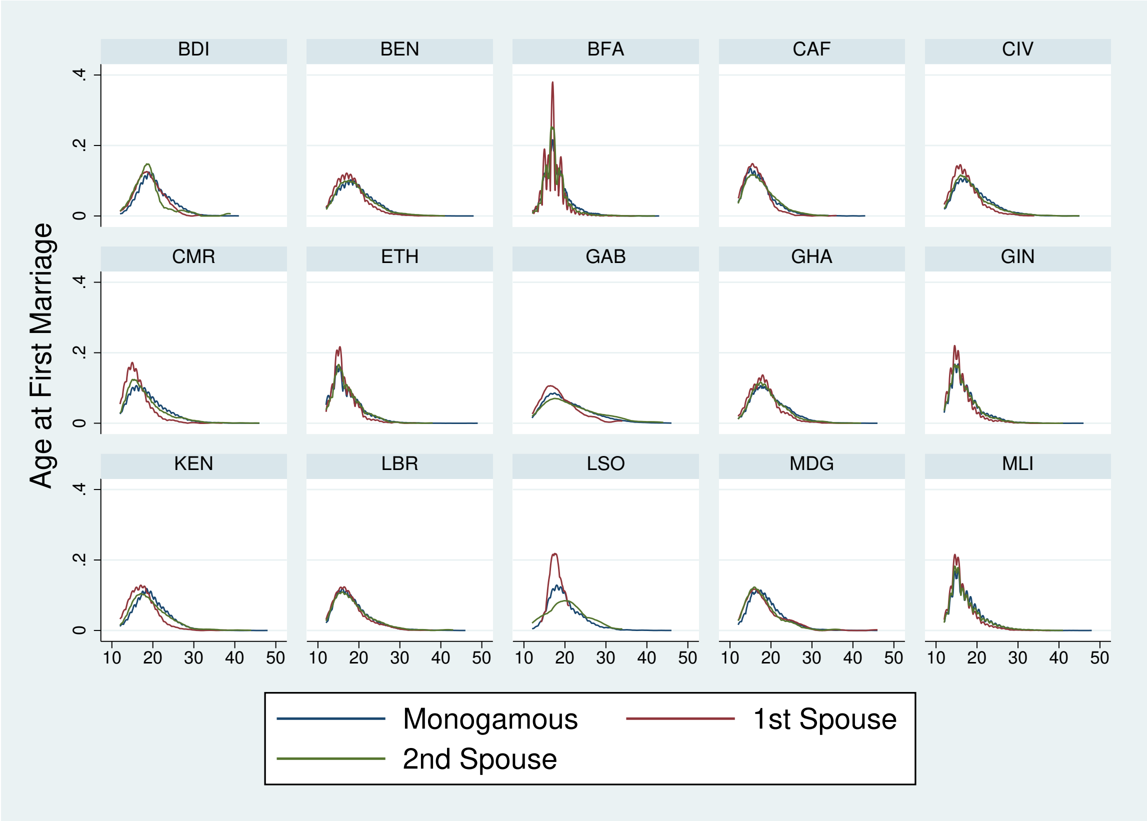
Figure A10: Distribution of Women by Number of Co-spouses



(a) Urban

(b) Rural

Figure A11: Age at First Marriage by Country



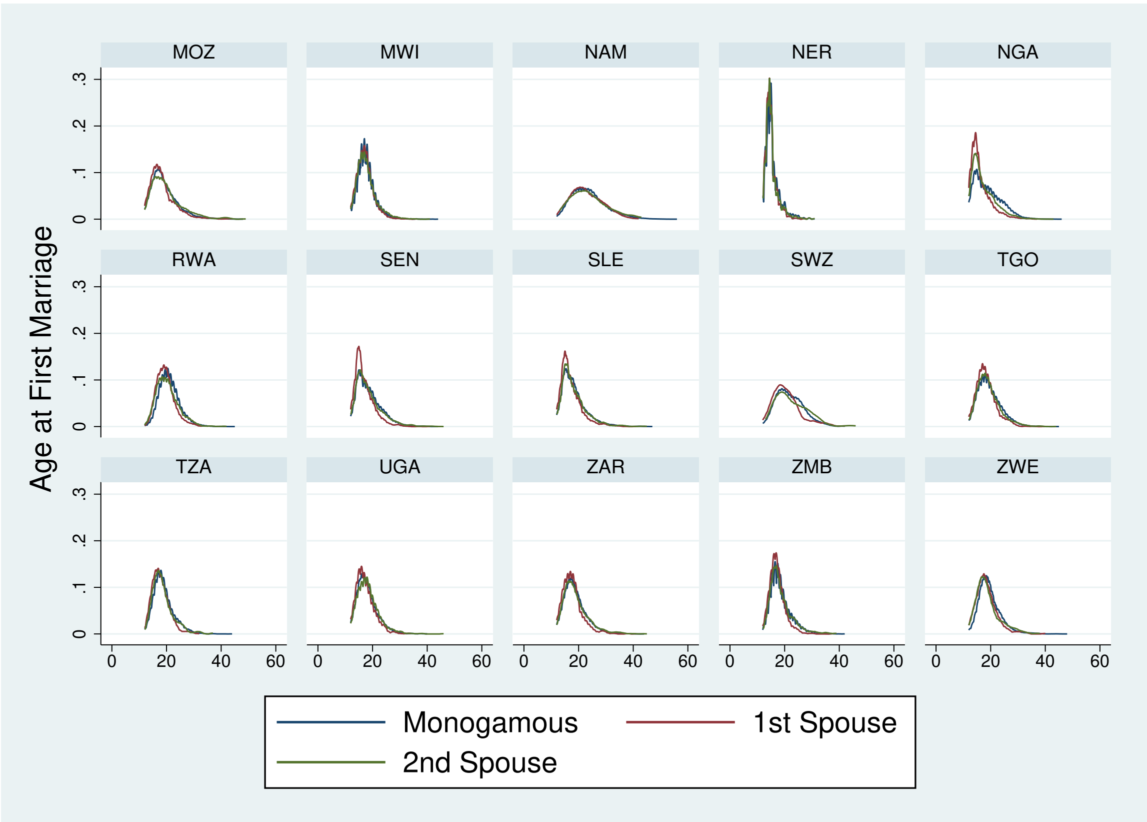


Figure A12: Age Gap between Husband and Wife by country

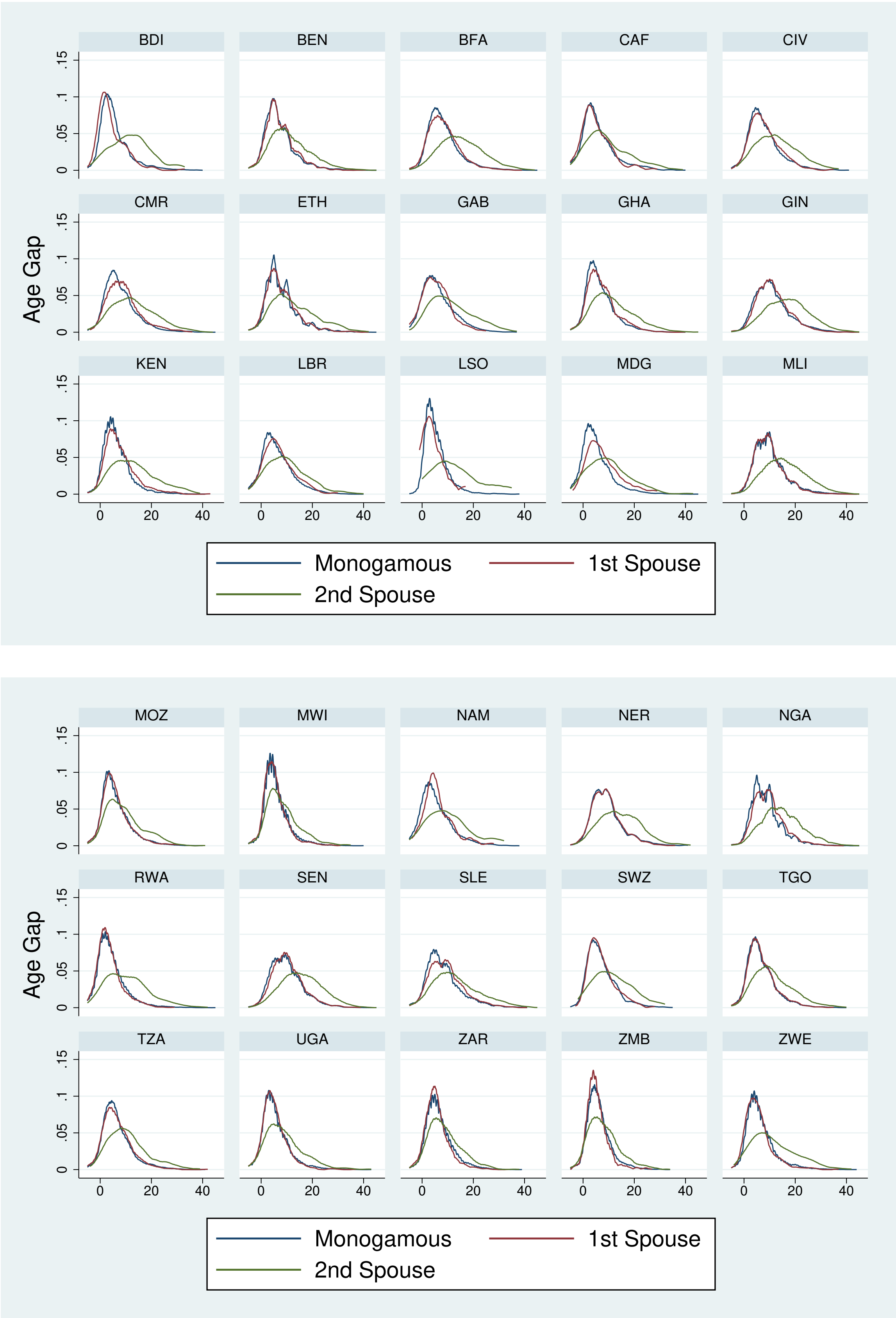
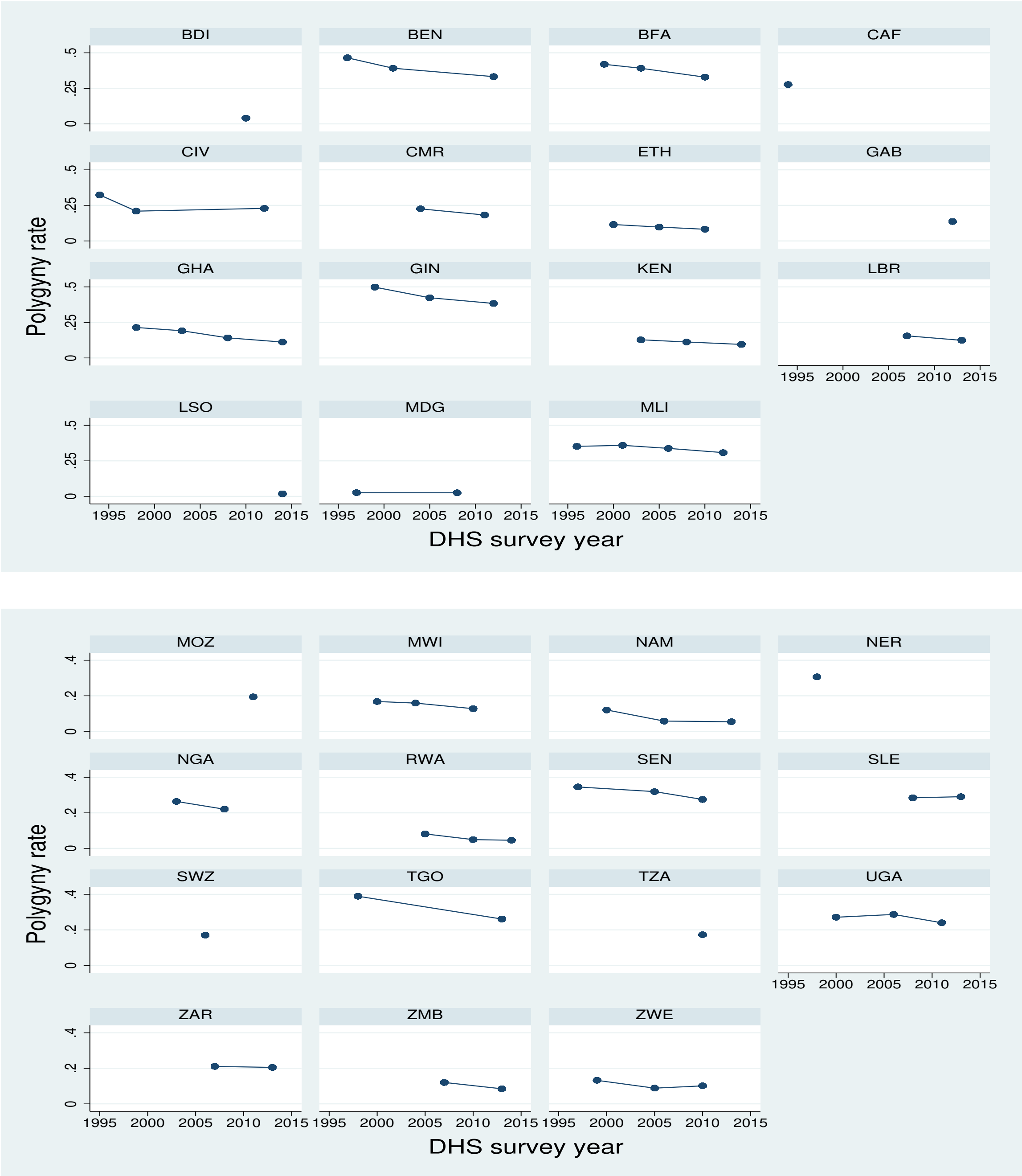


Figure A13: Evolution of Polygyny Rate over Time for Unions within last 10 Years



A.3 Alternative Specification for Prediction 1

To test prediction 1, we can also compare the characteristics of unions for women that marry during droughts to those that marry in normal years with the following regressions:

$$Y_{i,g,k,\tau} = \alpha D_{i,g,k,\tau} + \theta D_{i,g,k,\tau} \times P_g + \delta_\tau + \omega_g + \gamma_k + \epsilon_{i,g,k,\tau}$$

$$Y_{i,g,k,\tau} = \alpha^l D^l_{i,g,k,\tau} + \alpha^m D^m_{i,g,k,\tau} + \alpha^h D^h_{i,g,k,\tau} + \delta_\tau + \omega_g + \gamma_k + \epsilon_{i,g,k,\tau},$$

where $D_{i,g,k,\tau}$ is a dummy equal to 1 if the year τ in which woman i got married was a drought year and δ_τ is a set of marriage year fixed effects. These estimates are the result of both a potential negative selection effect (i.e., lower quality women are more likely to be married off during a drought year) and the causal effect (i.e., the fact that women who marry during a drought may have different marital outcomes because of changes in market composition on the demand side). The literature has, however, documented substantial evidence that high-ability women sort into marrying as first/unique spouses because it gives them better bargaining power (Reynoso, 2019; Matz, 2016; Munro et al., 2019). Such a sorting pattern taken at face value would imply $\alpha^h > 0$ if the only force at play were the negative selection effect for getting married during a drought. Getting $\alpha^h < 0$ as predicted by the model means that the selection effect plays a relatively minor role compared to the causal effect of droughts on the marital outcomes considered here. The estimated coefficients are, therefore, still informative about the causal effect despite the potential selection effect because they work in opposite directions. The results are shown in Table A1 and are consistent with those in Table 2.

A.4 Alternative Specification for Prediction 2

In this section, I study the impact of being exposed to any drought event between ages 12 and 17 (or 24) on the likelihood of marrying as a child bride (before 18) or before age 25. This specification uses the individual level data as opposed to the *person* $\times$ *age* level data used in the duration model. Results are presented in Table A2, and they are consistent with those from the duration model in Table 3. It shows that being exposed to any drought between ages 12 and 17 increases the likelihood of being married by age 18 only in low polygyny areas. The likelihood of child-marriage increases by 2.7 percentage

Table A1: Polygyny, Droughts at the Time of Union and Marriage Characteristics

	Husband age gap			Junior wife (2nd wife or higher order)		
	(1)	(2)	(3)	(4)	(5)	(6)
Drought x low polygamy		-0.0287	-0.0297		0.0033	
		(0.1363)	(0.1362)		(0.0046)	
Drought x medium polygamy		0.1392	0.1389		-0.0071	
		(0.1537)	(0.1537)		(0.0060)	
Drought x high polygamy		-0.3408**	-0.3412**		-0.0047	
		(0.1687)	(0.1687)		(0.0072)	
Drought	0.0809			-0.0003		-0.0197**
	(0.1531)			(0.0055)		(0.0096)
Drought x polygyny rate	-0.5260			-0.0087		
	(0.4380)			(0.0178)		
Age first marriage			-0.0685			
			(0.0694)			
Observations	224,936	224,936	224,936	226,130	226,130	71,149
Adjusted R-squared	0.1514	0.1514	0.1514	0.0814	0.0814	0.0636
Mean dependent variable	9.975	9.975	9.975	0.175	0.175	0.516

OLS regressions with observations at the individual level. The full sample includes married women aged 25 or older at the time of the survey. The dependent variables are the husband-wife age gap (columns 1-3) and whether a woman married as a junior wife (columns 4-6). All regressions include birth year FE, grid-cell FE, and marriage year FE. Column (6) restricts the sample to women in polygynous unions in medium and high polygyny areas. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. All Regressions are weighted using country population-adjusted survey sampling weights.

points in low polygyny areas (p<0.01) versus less than 0.5 percentage points for medium and 0.9 percentage points in high polygyny areas (p>0.1 for both coefficients).[61]

Columns (3), (4), and (5) show the impact of droughts on the likelihood of marrying before age 25. They significantly increase this likelihood by 3.4 percentage points in the absence of polygyny. This effect is significantly fading-out as the polygyny rate increases (column (3)). Column (4) shows the estimated impact for low, medium, and high polygyny areas. It shows that droughts have a positive and statistically significant impact on early marriage in low polygyny areas. They have no significant effect in medium polygyny areas, and they decrease this likelihood by 1.3 percentage points in high polygyny areas.[62] Column (5) splits drought exposure between ages 12 and 24 into exposure between 12 and 17 and between 18 and 24. The results confirm that we have the same pattern in both periods.

[61]The p-value of the difference between low and medium (high) polygyny is 0.067 (0.96).

[62]The p-values of the difference between these three coefficients are significant at 5% except the one between low and medium.

Table A2: Drought, Timing of Marriage, and Polygyny in Sub-Saharan Africa

	Married by age 18		Married by age 25		
	(1)	(2)	(3)	(4)	(5)
Any drought ages 12-17	0.0216***				
	(0.0081)				
Any drought ages 12-17 × polygyny rate	-0.0304				
	(0.0207)				
Any drought ages 12-17 × low polygyny		0.0273***			0.0386***
		(0.0094)			(0.0129)
Any drought ages 12-17 × medium polygyny		0.0051			0.0205*
		(0.0073)			(0.0124)
Any drought ages 12-17 × high polygyny		0.0086			-0.0107*
		(0.0059)			(0.0055)
Any drought ages 12-24			0.0347***		
			(0.0116)		
Any drought ages 12-24 × polygyny rate			-0.0857***		
			(0.0261)		
Any drought ages 12-24 × low polygyny				0.0333**	
				(0.0131)	
Any drought ages 12-24 × medium polygyny				0.0145	
				(0.0113)	
Any drought ages 12-24 × high polygyny				-0.0132**	
				(0.0057)	
Any drought ages 18-24 × low polygyny					0.0257*
					(0.0151)
Any drought ages 18-24 × medium polygyny					0.0048
					(0.0109)
Any drought ages 18-24 × high polygyny					-0.0176**
					(0.0075)
Observations	326,400	326,400	326,400	326,400	326,400
Adjusted R-squared	0.1654	0.1654	0.1155	0.1155	0.1157
Mean dependent variable	0.542	0.542	0.845	0.845	0.845

OLS regression with observations at the individual level. The full sample includes women aged 25 or older at the time of the survey. All regressions include age FE, birth year FE, and grid-cell FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is a dummy equal to 1 if a woman gets married before age 18 for columns 1-2 and a dummy equal to 1 if she gets married before age 25 for columns 3-5. The average proportion of women who marry before age 18 is 39.3%, 53.1% and 66.5% in low, medium, and high polygyny areas, respectively. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. All Regressions are weighted using country population-adjusted survey sampling weights.

A.5 Average Effect across Sub-Saharan Africa

This section replicates the main results in Corno et al. (2020) for Sub-Saharan Africa. The results presented in Table A3 show that women who experience a drought between ages 12 and 24 are 0.37 percentage points more likely to get married in the same year, which represents an increase of 3% in the annual hazard of early marriage. Columns (4) and (5) show that this effect is present only among women from an ethnic group that practice the bride price custom. Droughts do not affect the hazard of early marriage in the absence of marriage payment since marrying off a daughter does not provide extra resources to cope with the economic shock.

Table A3: Average Effect of Droughts on Early Marriage in Sub-Saharan Africa

	(1)	(2)	(3)	(4)	(5)
				Bride Price	
		All Sample		YES	NO
Drought	0.0037***	0.0037***	0.0032***	0.0037***	-0.0000
	(0.0012)	(0.0012)	(0.0011)	(0.0012)	(0.0021)
Observations	2,461,176	2,461,176	2,461,176	1,344,485	369,360
Adjusted R-squared	0.0616	0.0616	0.0621	0.0636	0.0646
Age FE	YES	YES	YES	YES	YES
Birth year FE	YES	YES	YES	YES	YES
Grid-cell FE	YES	YES	YES	YES	YES
Country FE	NO	YES	YES	YES	YES
Country FE x Cohort FE	NO	NO	YES	NO	NO
Mean dependent variable	0.112	0.112	0.112	0.118	0.127

Robust standard errors clustered at cell-grid level in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The table shows OLS regressions for Sub-Saharan Africa. The full regression sample includes women aged 25 or older at the time of the interview. Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. Standard errors (in parentheses) are clustered at the grid cell level. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. All Regressions are weighted using country population-adjusted survey sampling weights.

A.6 Supply Side Mechanism

The model proposed here can explain differences in how the equilibrium quantity of child marriage reacts to aggregate shocks in monogamous and polygynous marriage markets. It relies only on the difference in the structure of the demand side of the market and assumes no difference in the incentives on the supply side across these two types of markets. An alternative story could be that it is instead the differences in the reaction of the supply side that lead to different equilibrium outcomes. Polygyny allows the most desired men to re-enter the marriage market even after a first union. This means that for women, the option value of waiting and marrying later is higher in polygamous markets. The market's supply side can therefore be more elastic to income and price changes in polygamous markets than in monogamous ones. A similar argument has been proposed in Rexer (2022). He studies the impact of female exposure to income shocks during pre-marital adolescence on marriage inequality and how this fuels violence by making it easy to recruit young men for terrorist attacks. The paper treats rainfall shocks as idiosyncratic shocks that affect the supply side of the market and ignores their effect on the demand side.

I show that, if anything, the supply side mechanism only plays a minor role. This mechanism implies indeed that aggregate income shocks will have a stronger effect on the timing of marriage in polygamous markets. The empirical evidence documented in this paper supports the opposite: income shocks have stronger effects in monogamous markets than in polygamous ones. Table A4 shows that my main results are robust to using only the survey data from Nigeria, the country studied in Rexer (2022). Note that the interaction between conflict and marital decisions is a very complex one that I abstract from in this paper. I only focus on cohorts of girls that have not been exposed to any conflict by the time they turn 25 (i.e., before or during their prime marital age).

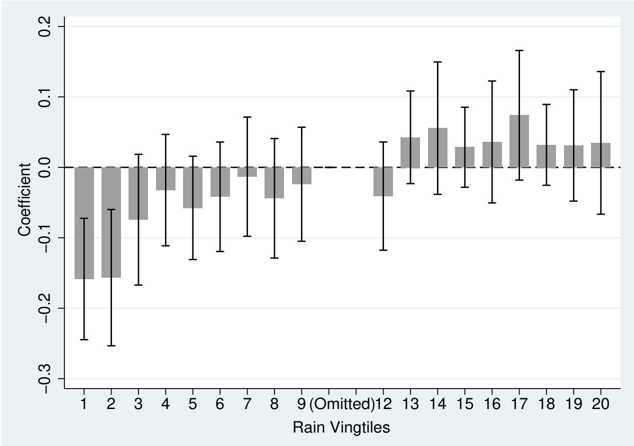
Table A4: Polygyny, Drought, and Timing of Marriage in Nigeria

	Hazard model: person × age observations				Person level observations	
	Married by 25		Married by 18		Married by 18	
	(1)	(2)	(3)	(4)	(5)	(6)
Drought	0.0207***		0.0182**			
	(0.0067)		(0.0085)			
Drought × polygyny rate	-0.0487**		-0.0417*			
	(0.0195)		(0.0227)			
Drought × low polygyny		0.0192***		0.0175**		
		(0.0053)		(0.0077)		
Drought × medium polygyny		-0.0010		-0.0039		
		(0.0047)		(0.0057)		
Drought × high polygyny		-0.0018		0.0003		
		(0.0060)		(0.0065)		
Any drought ages 12-17					0.0723**	
					(0.0290)	
Any drought ages 12-17 × polygyny rate					-0.1568**	
					(0.0634)	
Any drought ages 12-14 × low polygyny						0.0982**
						(0.0396)
Any drought ages 12-17 × medium polygyny						0.0027
						(0.0199)
Any drought ages 12-17 × high polygyny						0.0000
						(0.0138)
Observations	165,868	165,868	112,030	112,030	23,284	23,284
Adjusted R-squared	0.0702	0.0702	0.0979	0.0979	0.2901	0.2905
Mean dependent variable	0.116	0.116	0.105	0.105	0.570	0.570

All columns include age, birth year, and grid-cell fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Nigeria. Observations are at the person x age level from Column (1) to (4). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to a given observation for these columns. The observations in the sample are at the individual level in Columns (5) and (6), and the dependent variable is a dummy equal to 1 if the woman married before age 18. The full sample includes women aged 25 or older at the time of the interview (excluding those exposed to wars). A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. All Regressions are weighted using country population-adjusted survey sampling weights.

A.7 Other Tables and Graphs

Figure A14: Crop Yield by Rainfall Vintiles



Note: Coefficients of regression of the log of annual crop yield (tons per hectare) for five main staple crops (maize, sorghum, millet, rice, and wheat) on rainfall vingtiles. It uses country-level crop data over the period 1960–2010 from the FAOStat. The regression includes year and country fixed effects. Replication from Corno et al. (2020).

Table A5: Polygyny, PPI, and Timing of Marriage: Robustness to Religion

	Christians			Non-Christians		
	All	Rural	Urban	All	Rural	Urban
	(1)	(2)	(3)	(4)	(5)	(6)
PPI	-0.0024*	-0.0050**	0.0000	-0.0056*	-0.0082*	0.0011
	(0.0014)	(0.0024)	(0.0017)	(0.0030)	(0.0048)	(0.0034)
PPI × polygyny rate	0.0087*	0.0155**	0.0001	0.0127	0.0200	-0.0063
	(0.0052)	(0.0070)	(0.0080)	(0.0102)	(0.0148)	(0.0107)
Observations	1,010,451	583,406	427,045	394,101	260,375	133,726
Adjusted R-squared	0.0571	0.0653	0.0453	0.0698	0.0774	0.0564
Mean dependent variable	0.0995	0.116	0.0768	0.154	0.171	0.121

Hazard model with observations at *person* × *age* level. All regressions include age FE, birth year FE, grid-cell FE, and country × calendar year FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa. The full regression sample includes women aged 25 or older at the time of the interview. The PPI is measured in terms of average temporal standard deviations.

Table A6: Polygyny, PPI, and timing of Marriage: Robustness to Kinship System

	Not Matrilineal				Matrilineal			
	All	Rural		Urban	All	Rural		Urban
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PPI	-0.0033***	-0.0066***		0.0005	0.0035	0.0034		-0.0025
	(0.0010)	(0.0015)		(0.0009)	(0.0040)	(0.0054)		(0.0040)
PPI × polygyny rate	0.0045	0.0107**		-0.0037	-0.0305**	-0.0329*		-0.0056
	(0.0035)	(0.0051)		(0.0056)	(0.0150)	(0.0186)		(0.0139)
PPI × low polygyny			-0.0057***				-0.0012	
			(0.0013)				(0.0047)	
PPI × medium polygyny			-0.0045***				-0.0057	
			(0.0013)				(0.0048)	
PPI × high polygyny			-0.0001				-0.0043	
			(0.0019)				(0.0065)	
Observations	858,708	508,770	508,770	341,888	274,078	170,031	170,031	103,793
Adjusted R-squared	0.0648	0.0728	0.0728	0.0473	0.0619	0.0721	0.0721	0.0469
Mean dependent variable	0.125	0.144	0.144	0.0955	0.122	0.140	0.140	0.0929

Hazard model with observations at *person* × *age* level. All regressions include age FE, birth year FE, grid-cell FE, and country × calendar year FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa. The full regression sample includes women aged 25 or older at the time of the interview. The PPI is measured in terms of average temporal standard deviations.

Table A7: Polygyny, PPI, and Timing of Marriage by Crop Type

	Rural		Urban	
	(1)	(2)	(3)	(4)
PPI food crops	-0.0072***		0.0009	
	(0.0023)		(0.0014)	
PPI food crops × polygyny rate	0.0148**		-0.0078	
	(0.0069)		(0.0060)	
PPI cash crops	0.0004		-0.0004	
	(0.0009)		(0.0006)	
PPI cash crops × polygyny rate	0.0000		0.0031*	
	(0.0023)		(0.0018)	
PPI food crops × low polygyny		-0.0062***		0.0000
		(0.0020)		(0.0012)
PPI food crops × medium polygyny		-0.0027*		0.0002
		(0.0015)		(0.0014)
PPI food crops × high polygyny		-0.0001		-0.0038
		(0.0027)		(0.0027)
PPI cash crops × low polygyny		0.0007		-0.0001
		(0.0009)		(0.0005)
PPI cash crops × medium polygyny		-0.0000		0.0006
		(0.0007)		(0.0005)
PPI cash crops × high polygyny		0.0008		0.0007
		(0.0006)		(0.0008)
Observations	974,426	974,426	647,716	647,716
Adjusted R-squared	0.0702	0.0702	0.0472	0.0472
Mean dependent variable	0.134	0.134	0.0884	0.0884

Hazard model with observations at $person \times age$ level. All regressions include age FE, birth year FE, grid-cell FE, and country × calendar year FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa. The full regression sample includes women aged 25 or older at the time of the interview. The PPI is measured in terms of average temporal standard deviations.

Table A8: Droughts, Fertility, and Polygyny in Sub-Saharan Africa

	Any child before 15	Any child [15-17]		Number of children by 25	
	(1)	(3)	(4)	(5)	(6)
Any drought ages 12-14	-0.0011				
	(0.0028)				
Any drought ages 12-14 x polygamy rate	0.0015				
	(0.0099)				
Any drought ages 15-17		0.0201***			
		(0.0064)			
Any drought ages 15-17 x polygyny rate		-0.0377**			
		(0.0185)			
Any drought ages 15-17 x low polygyny			0.0212***		
			(0.0072)		
Any drought ages 15-17 x medium polygyny			0.0049		
			(0.0052)		
Any drought ages 15-17 x high polygyny			0.0040		
			(0.0059)		
Any drought ages 12-24				0.2056***	
				(0.0626)	
Any drought ages 12-24 x polygyny rate				-0.4419***	
				(0.1619)	
Any drought ages 12-24 x low polygyny					0.2012***
					(0.0768)
Any drought ages 12-24 x medium polygyny					0.0714*
					(0.0391)
Any drought ages 12-24 x high polygyny					-0.0144
					(0.0401)
Observations	326,400	308,584	308,584	326,400	326,400
Adjusted R-squared	0.0425	0.0584	0.0584	0.1522	0.1522
Mean dependent variable	0.0545	0.266	0.266	2.413	2.413

All regressions include age FE, birth year FE, and grid-cell FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa. Full regression sample: women aged 25 or older at the time of interview. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. Results are weighted using population-adjusted survey sampling weights.

Table A9: Polygyny, Droughts, and Timing of Marriage: Place of Residence and Education

	Full Sample				Bride price only			
	Residence		Any Schooling		Residence		Any Schooling	
	Rural	Urban	NO	YES	Rural	Urban	NO	YES
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Drought	0.0074***	0.0069**	0.0119**	0.0057**	0.0088***	0.0086***	0.0141**	0.0067***
	(0.0026)	(0.0028)	(0.0046)	(0.0024)	(0.0029)	(0.0028)	(0.0057)	(0.0025)
Drought x polygyny rate	-0.0166**	-0.0050	-0.0243**	-0.0072	-0.0201***	-0.0085	-0.0275**	-0.0126
	(0.0077)	(0.0106)	(0.0110)	(0.0099)	(0.0074)	(0.0100)	(0.0119)	(0.0096)
Observations	1,526,943	906,830	934,051	1,525,072	809,170	521,968	618,738	725,622
Adjusted R-squared	0.0689	0.0472	0.0711	0.0534	0.0724	0.0460	0.0766	0.0495
Mean dependent variable	0.126	0.0877	0.146	0.0909	0.134	0.0937	0.150	0.0906

All regressions include age FE, birth year FE, and grid-cell FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa (SSA). Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. The full sample includes women aged 25 or older at the time of the interview. The other columns restrict this sample to only women from an ethnic group where the bride price custom is practiced. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. All Regressions are weighted using country population-adjusted survey sampling weights.

Table A10: Polygyny, Droughts, and Timing of Marriage by Sub-Regions

	West Africa				Outside West Africa			
	Full Sample		Bride Price Only		Full Sample		Bride price only	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Drought	0.0153***		0.0118***		0.0030		0.0091***	
	(0.0042)		(0.0040)		(0.0024)		(0.0032)	
Drought x polygyny rate	-0.0313***		-0.0208**		-0.0065		-0.0425**	
	(0.0103)		(0.0090)		(0.0138)		(0.0182)	
Drought x low polygyny		0.0140***		0.0102**		0.0019		0.0055**
		(0.0046)		(0.0042)		(0.0018)		(0.0023)
Drought x medium polygyny		0.0035*		0.0061***		0.0027		-0.0006
		(0.0020)		(0.0022)		(0.0026)		(0.0035)
Drought x high polygyny		-0.0002		0.0001		-0.0011		-0.0153
		(0.0025)		(0.0019)		(0.0084)		(0.0123)
Observations	1,145,604	1,145,604	866,974	866,974	1,313,573	1,313,573	477,386	477,386
Adjusted R-squared	0.0633	0.0633	0.0680	0.0681	0.0619	0.0619	0.0568	0.0568
Mean dependent variable	0.127	0.127	0.128	0.128	0.0988	0.0988	0.101	0.101

All columns include age, birth year, and grid-cell fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa (SSA). Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. The full sample includes women aged 25 or older at the time of the interview. The other columns restrict this sample to only women from an ethnic group where the bride price custom is practiced. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. All Regressions are weighted using country population-adjusted survey sampling weights.

Table A11: Polygyny, PPI, and Timing of Marriage by Sub-Regions

	West Africa				Outside West Africa			
	Full Sample		Bride price only		Full Sample		Bride Price Only	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PPI	-0.0072***		-0.0065***		0.0000		-0.0063	
	(0.0023)		(0.0016)		(0.0038)		(0.0048)	
PPI × polygyny rate	0.0158**		0.0090*		-0.0003		0.0247	
	(0.0067)		(0.0053)		(0.0127)		(0.0168)	
PPI × low polygyny		-0.0060***		-0.0056***		-0.0001		-0.0058
		(0.0020)		(0.0014)		(0.0032)		(0.0043)
PPI × medium polygyny		-0.0029*		-0.0056***		0.0001		0.0002
		(0.0015)		(0.0014)		(0.0024)		(0.0025)
PPI × high polygyny		0.0007		-0.0003		-0.0005		0.0054
		(0.0024)		(0.0020)		(0.0046)		(0.0051)
Observations	424,935	424,935	318,190	318,190	549,491	549,491	192,528	192,528
Adjusted R-squared	0.0704	0.0704	0.0742	0.0742	0.0725	0.0725	0.0665	0.0665
Mean dependent variable	0.151	0.151	0.153	0.153	0.120	0.120	0.120	0.120

All columns include age, birth year, grid-cell, and country × calendar year fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa (SSA). Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. The full sample includes women aged 25 or older at the time of interview living in rural areas. The other columns restrict this sample to only women from an ethnic group where the bride price custom is practiced. The PPI is measured in terms of average temporal standard deviations. All Regressions are weighted using country population-adjusted survey sampling weights.

Table A12: Polygyny, Droughts, and Timing of Marriage: Samples with Substantial Within-country Variation

	Full Sample				Bride Price Only			
	$0.2 < \text{IQR} \leq 0.3$		IQR > 0.3		$0.2 < \text{IQR} \leq 0.3$		IQR > 0.3	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Drought	0.0132***		0.0103***		0.0132***		0.0115***	
	(0.0040)		(0.0037)		(0.0038)		(0.0040)	
Drought x polygamy rate	-0.0285**		-0.0535**		-0.0316***		-0.0550**	
	(0.0121)		(0.0238)		(0.0106)		(0.0263)	
Drought x low polygamy		0.0101***		0.0057**		0.0104***		0.0063**
		(0.0038)		(0.0025)		(0.0035)		(0.0026)
Drought x medium polygamy		0.0046**		-0.0002		0.0036		0.0021
		(0.0023)		(0.0045)		(0.0026)		(0.0047)
Drought x high polygamy		-0.0006		-0.0232		-0.0031		-0.0283
		(0.0037)		(0.0170)		(0.0032)		(0.0190)
Observations	713,618	713,618	283,538	283,538	470,469	470,469	261,872	261,872
Adjusted R-squared	0.0604	0.0604	0.0549	0.0549	0.0642	0.0642	0.0547	0.0547
Mean dependent variable	0.120	0.120	0.0991	0.0991	0.120	0.120	0.0981	0.0981

All columns include age, birth year, and grid-cell fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. IQR is the interquartile range of grid-cell level polygyny rates within each country. The sample with $IQR > 0.3$ includes the Democratic Republic of Congo, Kenya, Mozambique, and Uganda. The sample with $0.2 < IQR \leq 0.3$ includes Cameroon, Côte d'Ivoire, Ghana, Mali, Nigeria, Sierra Leone, and Tanzania. Observations are at the level of person x age. The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. The full sample includes women aged 25 or older at the time of the interview. The other columns restrict this sample to only women from an ethnic group where the bride price custom is practiced. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. All Regressions are weighted using country population-adjusted survey sampling weights.

Table A13: Polygyny, PPI, and Timing of Marriage: Samples with Substantial Within-Country Variation

	Full Sample				Bride Price Only			
	$0.2 < \text{IQR} \leq 0.3$		IQR > 0.3		$0.2 < \text{IQR} \leq 0.3$		IQR > 0.3	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PPI	-0.0072***		-0.0093*		-0.0064***		-0.0105*	
	(0.0023)		(0.0051)		(0.0015)		(0.0054)	
PPI × polygyny rate	0.0147**		0.0383*		0.0071		0.0470**	
	(0.0069)		(0.0219)		(0.0055)		(0.0233)	
PPI × low polygyny		-0.0060***		-0.0060		-0.0056***		-0.0065*
		(0.0020)		(0.0038)		(0.0013)		(0.0039)
PPI × medium polygyny		-0.0030*		-0.0004		-0.0059***		0.0004
		(0.0015)		(0.0028)		(0.0015)		(0.0028)
PPI × high polygyny		0.0004		0.0132		-0.0003		0.0162
		(0.0028)		(0.0128)		(0.0025)		(0.0125)
Observations	259,548	259,548	133,427	133,427	162,362	162,362	123,849	123,849
Adjusted R-squared	0.0679	0.0679	0.0631	0.0631	0.0723	0.0723	0.0638	0.0638
Mean dependent variable	0.143	0.143	0.118	0.118	0.147	0.147	0.116	0.116

All columns include age, birth year, grid-cell, and country × calendar year fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. IQR is the interquartile range of grid-cell level polygyny rates within each country. The sample with $IQR > 0.3$ includes the Democratic Republic of Congo, Kenya, Mozambique, and Uganda. The sample with $0.2 < IQR \leq 0.3$ includes Cameroon, Côte d'Ivoire, Ghana, Mali, Nigeria, Sierra Leone, and Tanzania. Observations are at the level of person x age. The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. The full sample includes women aged 25 or older at the time of the interview living in rural areas. The other columns restrict this sample to only women from an ethnic group where the bride price custom is practiced. The PPI is measured in terms of average temporal standard deviations. All Regressions are weighted using country population-adjusted survey sampling weights.

Table A14: Marriage Migration Patterns by Rainfall Realization at the Time of Marriage

	Born Here		Marriage Migration	
	(1)	(2)	(3)	(4)
Drought x low polygyny	-0.0003		-0.0020	
	(0.0082)		(0.0079)	
Drought x medium polygyny	-0.0096		0.0001	
	(0.0077)		(0.0056)	
Drought x high polygyny	0.0101		-0.0034	
	(0.0115)		(0.0097)	
Drought		-0.0049		0.0019
		(0.0088)		(0.0082)
Drought x polygyny rate		0.0167		-0.0118
		(0.0262)		(0.0243)
Observations	179,293	179,293	176,256	176,256
Adjusted R-squared	0.1565	0.1565	0.1012	0.1012
Mean dependent variable	0.408	0.408	0.172	0.172

All columns include Birth year FE, marriage year FE, and grid cell FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa. Full regression sample: married women aged 25 or older at the time of interview. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. Results are weighted using population-adjusted survey sampling weights.

Table A15: Marriage Migration Patterns by PPI at the Time of Marriage

	Rural		Urban	
	Born Here	Marriage Migration	Born Here	Marriage Migration
	(1)	(2)	(3)	(4)
PPI $\times$ low polygyny	-0.0115***	0.0125*	0.0048	0.0005
	(0.0037)	(0.0064)	(0.0036)	(0.0046)
PPI $\times$ medium polygyny	0.0006	0.0031	-0.0072	0.0168*
	(0.0058)	(0.0042)	(0.0083)	(0.0087)
PPI $\times$ high polygyny	-0.0141*	0.0112*	0.0421*	0.0104
	(0.0076)	(0.0065)	(0.0215)	(0.0103)
Observations	75,097	73,867	29,943	29,294
Adjusted R-squared	0.1829	0.1154	0.1594	0.0980
Mean dependent variable	0.429	0.214	0.308	0.169

All columns include Birth year FE, marriage year FE, and grid-cell FE. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for Sub-Saharan Africa. Full regression sample: married women aged 25 or older at the time of interview. The PPI is measured in terms of average temporal standard deviations. Results are weighted using population-adjusted survey sampling weights.

Table A16: Robustness to the Definition of Polygyny Rate: Droughts

	Married by age 25			
	(1)	(2)	(3)	(4)
Drought	0.0096***	0.0074***		
	(0.0021)	(0.0020)		
Drought x Polygyny rate (1st wave)	-0.0184***			
	(0.0060)			
Drought x Polygyny rate (last wave)		-0.0132*		
		(0.0068)		
Drought x Low polygyny (1st wave)			0.0081***	
			(0.0021)	
Drought x Medium polygyny rate (1st wave)			0.0037**	
			(0.0018)	
Drought x High polygyny rate (1st wave)			-0.0015	
			(0.0025)	
Drought x Low polygyny (last wave)				0.0059***
				(0.0018)
Drought x Medium polygyny rate (last wave)				0.0041**
				(0.0020)
Drought x High polygyny rate (last wave)				0.0018
				(0.0024)
Observations	1,985,343	2,246,344	1,985,343	2,246,344
Adjusted R-squared	0.0598	0.0607	0.0598	0.0607
Mean dependent variable	0.111	0.111	0.111	0.111

All columns include age, birth year, and grid-cell fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table shows OLS regressions for countries with at last two DHS survey waves. Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. A drought is defined as an annual rainfall realization below the 15th percentile of the local rainfall distribution. Results are weighted using population-adjusted survey sampling weights.

Table A17: Robustness to the Definition of Polygyny Rate: PPI Shocks

	ALL		Rural		Urban	
	(1)	(2)	(3)	(4)	(5)	(6)
PPI	-0.0027**	-0.0031**	-0.0064***	-0.0066***	0.0009	0.0006
	(0.0013)	(0.0012)	(0.0023)	(0.0022)	(0.0015)	(0.0013)
PPI $\times$ polygyny rate (1st wave)	0.0043		0.0115**		-0.0045	
	(0.0043)		(0.0058)		(0.0053)	
PPI $\times$ polygyny rate (last wave)		0.0082*		0.0158**		-0.0018
		(0.0042)		(0.0064)		(0.0052)
Observations	1,400,684	1,606,094	802,502	954,825	589,804	642,891
Adjusted R-squared	0.0612	0.0621	0.0690	0.0701	0.0469	0.0464
Mean dependent variable	0.115	0.115	0.134	0.133	0.0882	0.0880

Hazard model with observations at $person \times age$ level. All regressions include age FE, birth year FE, grid-cell FE, and country $\times$ calendar year FE. The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. The PPI is measured in terms of average temporal standard deviations.

Table A18: Polygyny, Weather Shocks, Crop Yield, and Income

	Crop yield		HH consumption		GDP per capita	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Drought	-0.125***		-0.0652**		-0.0482*	
	(0.0271)		(0.0284)		(0.0274)	
Drought x Low Polygyny		-0.142***		-0.0433		-0.00398
		(0.0391)		(0.0394)		(0.0261)
Drought x High Polygyny		-0.109***		-0.0835		-0.0912*
		(0.0374)		(0.0505)		(0.0451)
Observations	1,670	1,670	1,335	1,335	1,455	1,455
Adjusted R-squared	0.736	0.736	0.950	0.950	0.917	0.917
Mean dependent variable	-0.109	-0.109	21.19	21.19	6.756	6.756

All regressions include year and country fixed effects. The dependent variable is the log of annual crop yield (tons per hectare, columns 1–2), household consumption (columns 3–4), and GDP per capita (columns 5-6) for each included country from 1961 to 2010. Crop yield data are from FAOStat; income data are from the World Development Indicators from the World Bank for 1960–2013. Regressions include all SSA countries in the FAOStat and WDI databases. In columns 1 and 2, the dependent variable is the log of the sum of the total production of main crops reported divided by the total area harvested for those crops. GDP per capita is measured in constant 2010 US$, while household final consumption expenditures are measured at the aggregate level in current US$. A drought is defined as an annual rainfall realization below the 15th percentile of the national rainfall distribution. High polygyny countries are countries with average polygyny rates higher than 0.25. It includes Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Cote d'Ivoire, the Democratic Republic of the Congo, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Swaziland, Togo. Standard errors (in parentheses) are clustered at the country level.

Table A19: Robustness to Continuous Rainfall Measure

	Bride price		No bride price	
	(1)	(2)	(3)	(4)
Log (Rainfall)	-0.0120**		-0.0011	
	(0.0048)		(0.0060)	
Log (Rainfall) x Polygyny rate	0.0309**		-0.0067	
	(0.0141)		(0.0264)	
Log (Rainfall) x Low polygyny		-0.0104**		-0.0028
		(0.0046)		(0.0049)
Log (Rainfall) x Medium polygyny		-0.0027		-0.0000
		(0.0035)		(0.0049)
Log (Rainfall) x High polygyny		0.0050		-0.0092
		(0.0047)		(0.0115)
Observations	1,344,360	1,344,360	369,241	369,241
Adjusted R-squared	0.0636	0.0636	0.0645	0.0645
Mean dependent variable	0.118	0.118	0.127	0.127

All columns include age, birth year, and grid-cell fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. Results are weighted using population-adjusted survey sampling weights. The sample is split between girls from ethnic groups that traditionally practice bride price payment or not based on the Murdock Ethnographic Atlas.

Table A20: Polygyny, Droughts, and Timing of Marriage: Robustness to Time Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)
Drought	0.0063***		0.0059***		0.0034	
	(0.0021)		(0.0020)		(0.0023)	
Drought × polygyny rate	-0.0136**		-0.0163**		-0.0179**	
	(0.0066)		(0.0065)		(0.0073)	
Drought × low polygyny		0.0050**		0.0046**		0.0017
		(0.0021)		(0.0019)		(0.0021)
Drought × medium polygyny		0.0028*		0.0014		-0.0017
		(0.0016)		(0.0016)		(0.0019)
Drought × high polygyny		-0.0010		-0.0026		-0.0056**
		(0.0024)		(0.0024)		(0.0026)
Observations	2,459,177	2,459,177	2,459,177	2,459,177	2,459,177	2,459,177
Adjusted R-squared	0.0625	0.0625	0.0636	0.0636	0.0651	0.0651
Calendar year FE	YES	YES	YES	YES	NO	NO
Country × time trend	NO	NO	YES	YES	NO	NO
Country × calendar year FE	NO	NO	NO	NO	YES	YES
Mean dependent variable	0.112	0.112	0.112	0.112	0.112	0.112

All columns include age, birth year, and grid-cell fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. Results are weighted using population-adjusted survey sampling weights.

Table A21: Current, Lagged, Future droughts, and Timing of Marriage by Polygyny Levels

Polygyny level:	Low	Medium	High
	(1)	(2)	(3)
Drought	0.0060***	0.0038**	0.0007
	(0.0019)	(0.0016)	(0.0024)
Drought Lead 1	0.0005	0.0017	0.0003
	(0.0016)	(0.0019)	(0.0024)
Drought Lag 1	0.0006	-0.0020	-0.0017
	(0.0017)	(0.0019)	(0.0022)
Observations	938,991	810,915	704,377
Adjusted R-squared	0.0504	0.0533	0.0671
Mean dependent variable	0.0858	0.113	0.146

All columns include age, birth year, and grid-cell fixed effects. Robust standard errors clustered at cell-grid level in parentheses *** p<0.01, ** p<0.05, * p<0.1. Observations are at the level of person x age (from 12 to 24 or age of first marriage). The dependent variable is a binary variable for marriage, coded to one if the woman married at the age corresponding to the observation. Results are weighted using population-adjusted survey sampling weights.