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Weather Shocks, Age of Marriage and the Direction of Marriage Payments*

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Abstract

In this paper, we examine the impact of variation in local economic conditions on the hazard into child marriage (i.e. prior to age 18) among young women in Africa and India. We show that rainfall shocks, a major source of income variation in these areas, have similar effects on crop yields but opposite effects on the early marriage hazard in the two regions: in Africa, droughts increase the hazard into early marriage, while in India, droughts decrease the hazard. We argue that the differential impact of drought on the marriage hazard can be explained by differences in the direction of traditional marriage payments in each region (bride price in Africa and dowry in India). Our results highlight the importance of understanding the relationship between prevailing cultural norms and household responses to economic shocks; as we show here, differences in prevailing customs

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can result in dramatically different household responses to aggregate income fluctuations.

JEL Codes: J1, O15.

Keywords: Income shocks, informal insurance, marriage, Africa, India, dowry, bride

1 Introduction

Despite improvements in female educational and economic opportunities, large numbers of young women in developing countries continue to marry at an early age. Child marriage (defined as marriage before the age of 18) is especially pronounced among women living in rural areas of Sub-Saharan Africa and South Asia, where more than 50% of women continue to marry before age 18, and 20% marry before age 15.[1] Early marriage is associated with a wide range of adverse outcomes for women and their offspring, including higher rates of domestic violence; harmful effects on maternal, newborn, and infant health; reduced sexual and reproductive autonomy; and reduced literacy and educational attainment (Jensen and Thornton, 2003; Field and Ambrus, 2008). Based on these findings, international organizations such as UNICEF and the World Bank have called for "urgent action", arguing that the eradication of early marriage is a necessary step towards improving female agency and autonomy around the world.[2]

Understanding the driving forces behind early marriage is crucial to successfully reduce it. Yet, the evidence base in this area is surprisingly weak.

[1] Figures are based on DHS surveys for India (2005) and Africa (2006-2012), considering women aged 20-24 living in rural areas.

[2] See "No time to lose: New UNICEF data show need for urgent action on female genital mutilation and child marriage", UNICEF Press Release, 22 July 2014.

Social and cultural factors certainly play an important role, but economic factors are also important. Moreover, economic factors and societal and cultural norms are likely to interact with one other, contributing to the complexity of the phenomenon. In this paper, we provide new evidence on one way in which economic conditions and cultural institutions interact to affect the prevalence of early marriage in developing countries. We investigate the impact of rainfall shocks –a major source of income variability in rural areas– on the hazard into early marriage among young women in Africa and India. We show that droughts (negative income shocks) have opposite effects on the marriage hazard in these two regions: in Africa, droughts increase the hazard rate into early marriage, while in India, droughts reduce the hazard. Specifically, we find that drought reduces the early marriage hazard by 0.2 percentage points in rural Africa and increases the early marriage hazard by 0.8 percentage points in rural India.

We document that droughts have a significantly negative impact on crop yields, and hence on household income, in both regions. Then, we argue that the reason for the differential impacts across the two regions can be explained by differences in the direction of traditional marriage payments. In India, the prevailing tradition is for the bride's family to pay a dowry to the groom's family at the time of marriage, whereas in Africa, it is customary for the groom's family to pay a bride price to the bride's family.

Within the context of formulating policy to prevent early marriage, our results highlight the importance of understanding the interdependencies between prevailing social and cultural norms and household responses to economic hardship: as we show here, differences in prevailing customs can re-

sult in dramatically different household responses to negative income shocks. More broadly, our results contribute to the large economic literature that studies the coping mechanisms used by poor households to deal with income risk. Despite imperfect markets for formal insurance, credit, and assets, rural households seem well-equipped to smooth consumption in the face of short-term, idiosyncratic income shocks, often through informal, inter-village insurance arrangements (Townsend, 1994). However, in the face of aggregate shocks, households must rely on a different set of strategies to cope (Dercon, 2002). These strategies, which include migration, off-farm employment, and liquidation of buffer stock, are often not very successful at smoothing consumption, leaving household members exposed to (potentially serious) detrimental effects on longer-run welfare. This is illustrated in the growing empirical literature looking at the impact of negative rainfall shocks on individual outcomes, which has identified negative effects of drought on infant and child health, schooling attainment and cognitive test score performance, increased rates of domestic violence and violence against women, and even higher rates of HIV infection.[3] Here, we show that adjusting the timing of marriage is another strategy that households use to cope with aggregate variation in income, which can have harmful long-run welfare implications for young women.

Our findings also contribute to the large body of literature showing how cultural norms and practices shape economic development (Fernandez, Fogli, and Olivetti, 2004; Fernandez and Fogli, 2009; Algan and Cahuc, 2010; Alesina,

[3]See Dell, Jones, and Olken (2013) for a comprehensive review of this literature. For findings on the link between drought and HIV infection rates, see Burke, Gong, and Jones (2014).

Algan, Cahuc, and Giuliano, 2010).

The remainder of the paper proceeds as follows. Section 2 provides background information on marriage markets, marriage payments, and early marriage in India and Africa. Section 3 describes the data used in the analysis, and Section 4 explains the empirical and identification strategy. Sections 5 and 6 summarize the results and provide robustness checks. Section 7 concludes.

2 Marriage Institutions in Sub-Saharan Africa and India

2.1 Early marriage

Early marriage continues to persist in developing countries around the world, but it is most prevalent in rural areas of South Asia and Sub-Saharan Africa (West and Central Africa, in particular). The reasons why the practice persists are numerous and inter-related. Parents often view early marriage as a socially acceptable strategy to protect their daughter against events (rape and sexual assault, out-of-wedlock pregnancy, etc.) that could compromise her purity and subsequent marriageability (see for example Worldvision (2013); Bank (2014)). Grooms also tend to express a preference for younger brides, purportedly due to beliefs that younger women are (1) more fertile; (2) more likely to be sexually inexperienced; and (3) easier to control (Field and Ambrus, 2008).

Although cultural and social norms are important drivers of the persis-

tence of early marriage, a household's economic circumstances also play a role. Girls from poor households are almost twice as likely to marry early as compared to girls from wealthier households (Bank, 2014), in large part because women in these regions are usually viewed as a net economic burden: marrying a daughter earlier means that there is "one less mouth to feed." This effect is compounded by the tradition of marriage payments (dowry and bride price) in both regions. In India, the prevailing tradition is for the parents of the bride to pay a dowry to the groom's family at the time of marriage, while in Africa, bride price is traditionally paid by the groom to the parents of the bride. The available empirical evidence indicates that dowry is increasing in bride's age, while bride price is decreasing in bride's age, meaning that under both customs, marrying a daughter earlier is economically more attractive for her parents.[4]

Although some boys are also at risk, the practice of early marriage is almost entirely a female phenomenon. This pattern generates a significant age gap between husband and wife, which is exacerbated when girls marry at younger ages.

2.2 Dowry and bride price

The prevailing economic view of marriage payments is based on the seminal work of Becker (1991). In this framework, marriage is viewed as a joint venture that provides greater productive efficiency than is possible if both partners remain single. Individuals enter into the marriage market to find the

[4]For evidence on the relationship between dowry and bride's age in India, see Chowdhury (2010). Empirical data on bride price is extremely limited, but for evidence on bride price and bride's age in Zimbabwe, see Hoogeveen, Klaauw, and Lomwel (2011).

match that maximizes their expected utility; the marriage market matches partners and determines the division of returns between them. Given this characterization, marriage payments (dowries and bride prices) may emerge as pecuniary transfers that serve to clear the marriage market. For instance, marriage payments can emerge in response to scarcity on one side of the marriage market: when grooms are relatively scarce, brides pay dowries to grooms, and when brides are relatively scare, grooms pay bride prices to brides. A slightly different formulation of this argument can be made if one assumes that the rules for division of household output are inflexible, so that a spouse's shadow price in the marriage market differs from his or her share of household output. In this situation, marriage payments will emerge as up-front transfers to equilibrate the market. In cases where the woman's shadow price on the marriage market is less than her share of household output, a bride price will emerge to encourage her to marry; in the opposite case, when a woman's shadow price on the marriage market is more than her share of household output, dowries will emerge to encourage male participation on the market.[5]

There is an important difference between marital customs in sub-Saharan Africa and India: in Africa, bride price is the prevailing norm, while in India,

[5]Traditionally, dowry appears to have served mainly as a pre-mortem bequest made to daughters rather than as a payment used to clear the marriage market (Goody and Tambiah, 1973). However, with development, dowry appears to have taken on a function more akin to a groomprice, a price that brides' parents must pay in order to ensure a husband for their daughter. The transition of the property rights over dowry from the bride to her husband is discussed in Anderson and Bidner (2015), who document a similar transition in late-middle ages in Europe. The view of dowry as a pre-mortem bequest to daughters is also at odds with the prevalence of dowry violence in India, whereby grooms threaten domestic violence in order to get higher transfers from their wife's parents (see Bloch and Rao (2002)).

dowry is the accepted custom. Traditionally, the practices of bride price was near-ubiquitous across the sub-Saharan African sub-continent: more than than 90% of ethnic groups in sub-Saharan Africa traditionally paid bride price (Goody, 1976; Murdock, 1967). This practice is not universal in contemporary Africa, but it remains a substantial transfer across the region (see appendix table A3). For example, a household panel survey conducted in Zimbabwe in the mid-1990s revealed near-universality of bride price at the time of marriage; average bride wealth in this data (received primarily in the form of heads of cattle) was estimated to be two to four times a household's gross annual income (Decker and Hoogeveen, 2002). Relying on DHS data, Anderson (2007) reports that bride price was paid in about two-thirds of marriages in rural Uganda in the 1990s, down from 98% in the period between 1960-1980 and 88% from 1980-1990. In a large-scale survey conducted by Mbaye and Wagner (2013) in rural Senegal in 2009-2011, bride price was found to have been paid in nearly all marriages. Ashraf, Bau, Nunn, and Voena (2015) document that the practice is modern-day widespread Lusaka (Zambia), with payments often exceeding annual per capita GDP.

In a recent paper, Corno and Voena (2015) examine the relationship between idiosyincratic rainfall shocks and age at marriage in the Kagera region in Tanzania. They show that negative shocks in the cluster of birth of a girl increase her probability of marriage by age 18. They use such a finding to estimate the dynamic optimization problem faced by the girl's family, which in the absence of credit markets chooses the timing the marriage of their daughter to obtain a bride price payment and smooth consumption. They show that the bride price can play a significant role in consumption insurance

when markets are incomplete.

In contemporary India, dowry is paid in virtually all marriages (Anderson, 2007). Interestingly, although dowry has been practiced in Northern India for centuries, it is a much more recent phenomenon in the South, where bride price traditions were formerly the norm. The transition from bride price to dowry began in the start of the 20th century, and has been attributed to an increasingly skewed sex ratio (more potential brides than potential grooms), which has increased competition among women for grooms, particularly educated young men with urban jobs (Caldwell, Reddy, and Caldwell, 1983). The magnitude of dowry payments appears to have grown substantially over the first half of the twentieth century, a phenomenon which has been explained by population growth, which along with the large age gap at marriage generates more potential brides than available grooms in the market (the so-called "marriage squeeze"), as well as hypergamy and the caste system (Anderson, 2003; Rao, 1993; Sautmann, 2012). Over the period we study in our data, dowry is widespread across India and payments are large in magnitude (often significantly above average household income).[6]

There are numerous explanations proffered to explain the existence of dowry in India and bride price in Africa. Goody and Tambiah (1973) explain the prevalence of bride price in Africa by the continent's land abundance and low population density. The relative scarcity of labor requires men to compensate the bride's family for losing her labor, and increases the value of the woman's ability to produce offspring. In contrast, in South Asia where population density is high and land is scarce, men are distinguished by their

[6]Other work has examined the tole of dorwy in Europe, see Botticini (1999); Botticini and Siow (2003).

land holdings, and women's own labor and ability to reproduce is relatively less valued. Boserup (1970) offers a slightly different hypothesis based on differences in women's agricultural productivity in the two regions. She argues that in Africa, which has a non-plough agricultural system, female labor is more important than in Asia, a region characterized by plough architecture, which generates marriage payments that move towards the bride's side of the market. This hypothesis finds empirical support in Giuliano (2014).

2.3 Marriage Migration and Patrilocal Exogamy

In India and in much of Africa, societies are patrilocal, meaning that at the time of marriage, a daughter joins the household of the groom and his family at the time of marriage. Often, parents marry their daughter to a groom residing in a different village, which could be quite far from her natal home. Rosenzweig and Stark (1989) argue that this phenomenon, sometimes referred to as "marriage migration," is adopted to informally insure families against shocks: marrying a daughter to a man in a distant village reduces the co-movement of parental household income and daughter's household income, which facilitates the possibility of making inter-household transfers in times of need. This explanation is questioned in recent work by Fulford (2013), who shows that inter-household transfers are virtually non-existent and that households in areas with high rainfall volatility do not send daughters to more distant villages, as might be expected under the theory.

Understanding the marriage migration phenomenon is essential to our identification strategy; in our analysis, we rely on retrospective information about women's age at first marriage, and while we have detailed information

on where women reside today, we lack information on where they lived when they were on the marriage market. In order to be able to link weather shocks to women, therefore, we need to assume that women are currently living relatively close to the place they lived prior to their marriage. As we show in more detail appendix B, while virilocality is common in both regions, the available data on marriage migration indicates that most women do not move far from their natal home. For example, according to the India Human Development Survey (IHDS), the average travel time between a woman's current residence and her natal home is about 3 hours; and in Rosenzweig and Stark's data, the average distance between a woman's current place of residence and her natal home is 25km (see table B1). In Africa, marriage migration is even less prevalent, and when it does occur, also appears to be across relatively short distances. For example, in the set of African countries we study in our analysis, more than 40% of women report never moving from their natal home (see Figure B1). Mbaye and Wagner (2013) collect data in Senegal which find that women live an average of 20 kilometers from their natal home. Altogether, the available information on marriage migration in Africa and India suggest that most women that move from their natal home at the time of marriage are not moving out of the geographic areas for which we define our weather shocks, which strengthens the credibility of our analysis.

3 Data

All datasets used in this analysis are summarized in appendix table A1. Below, we provide a more detailed description of the sources of data.

3.1 Marriage data

To examine how weather shocks impact marriage outcomes for young women, we use data from the Demographic and Health Surveys (DHS) for sub-Saharan Africa and from the DHS and India Human Development Survey (IHDS) for India.[7] For sub-Saharan Africa, we use all DHS surveys from 1994-2012 where GPS (geographical positioning system) data are available, resulting in a total of 60 surveys across 30 countries. In these surveys, GPS data consist of the geographical coordinates of each DHS cluster (group of villages or urban neighborhoods) in the sample. The list of countries and survey waves included in the analysis is reported in the appendix table A2. For India, we use the DHS survey from 1998 and the IHDS survey from 2004-05. The two Indian surveys do not contain GPS coordinate information; instead, they provide information on each woman's district of residence, which we can use to match the data to weather outcomes.[8]

[7] DHS surveys are nationally-representative, household-level surveys carried out in developing countries around the world. The DHS program is funded by USAID, and has been in existence since the mid-1980s. Over 130 DHS surveys have been conducted in about 70 countries since the program's inception. The India Human Development survey is a nationally-representative, household-level survey first carried out in 2004-05. A second wave was held in 2011-12, but is not yet publicly available.

[8] The DHS India surveys are also referred to as the National Family Health Surveys (NFHS). There are two additional DHS surveys available for India: one conducted in 1992, and one conducted in 2005, but they do not provide information on women's district of residence, which is why we use the IHDS.

The main variable of interest is a woman's age at first marriage. Across all the surveys, this information is collected retrospectively during the female interview: women are asked to recall the age, month and year when they were first married.[9] The main difference across the surveys is the universe of women that is sampled for the female interview. In the DHS-Africa surveys, all women in the household between the ages of 15-49 are interviewed. In contrast, in the DHS-India surveys, all ever-married women aged 15-49 in the household are interviewed; and in the IHDS, only one ever-married woman aged 15-49 is interviewed in each household. In order to ensure comparability across surveys and avoid bias resulting from the omission of never-married women in the India sample, we limit our analysis to women that are at least 25 years old at the time of the interview. By this point, most women are married and so the omission of never-married women in the India sample should not be a major concern.[10]

Finally, we drop the small number of women born prior to 1950, so that our analysis looks exclusively at women born from 1950 through the mid-1980s. For most of our analyses, we focus on women living in rural areas. After making the restrictions described here, our final sample consists of about 235,000 women in rural parts of sub-Saharan Africa, and 63,000 women in rural parts of India.

[Insert Table I]

Table I presents summary statistics for our main sample of women (i.e.

[9] The India DHS does not ask month of first marriage.

[10] As a robustness check, we also run our analysis on the sample of ever-married women and show that our results are very similar. See Section 5 for more detail.

rural women, aged 25 and older at the time of interview, born after 1950). There are four main takeaways from the table. First, the mean age of marriage is low, and significant proportions of women are marrying before age 18. The mean age at first marriage is 16.5 years in India and 17.4 years in Africa, and the percent of women marrying prior to age 18 is 66.4% and 56.3% in India and Africa, respectively. Second, in both regions, the prevalence of early marriage is falling over time, but remains pervasive even amongst women born in the 1980s. The rate of decline in early marriage is more than twice as large in Africa as in India, which has widened the disparity in the prevalence of early marriage across the two regions. Third, in both regions, women that never attend formal schooling are significantly more likely to marry early than women with at least some formal education. This is likely explained by the fact that poorer women are both less likely to attend school and more likely to marry early. Finally, the age gap between husbands and wives is large in both regions –6.2 years in India and 8.8 years in Africa– and is even larger among women marrying before age 18.

[Insert Figure I]

Figure I plots the hazard and survival functions for our main sample. The hazard and survival curves for the two regions have the same basic shape, at least through age 20, although the African survival (hazard) curve lies above (below) the Indian survival curve from age 14 onward. In both regions, the hazard into early marriage is very low up until age 13 or 14, which is consistent with the finding that girls are often considered to be ready to marry at the onset of puberty, which usually occurs sometime in the early

teenage years (see Field and Ambrus, 2008). Women seem to be at highest risk of marrying early when they are in their mid-teens (between ages 16 and 17).

3.2 Weather data and construction of weather shocks

The goal of this paper is to understand how economic shocks affect the early marriage hazard for young women. Following an approach that is widely used in the literature, we use variation in rainfall as a proxy for variation in local economic conditions. The appeal of this approach is that rainfall is an exogenous event that has meaningful effects on economic productivity in rural parts of Africa and India, where most households continue to rely heavily on rain-fed agriculture for their economic livelihood (Jayachandran, 2006; Schlenker and Lobell, 2010; Shah and Steinberg, forthcoming; Burke, Gong, and Jones, 2014). Negative rainfall shocks (i.e. droughts), in particular, tend to suppress agricultural output, which has deleterious effects on households' incomes.

We use rainfall data produced by geographers at the University of Delaware ("UDel data") to construct rainfall shock measures that capture anomalously high and low rainfall realizations relative to what is typically experienced in a particular location. The UDel dataset provides estimates of monthly precipitation on a 0.5 x 0.5 degree grid covering terrestrial areas across the globe, for the period 1900-2010.[11] For Africa, we use the GPS information in the DHS

[11] 0.5 degrees is equivalent to about 50 kilometers at the equator. The rainfall estimates in the UDel data are based on climatologically-aided interpolation of available weather station information, and are widely relied upon in the existing economic literature Dell, Jones, and Olken (2012); Burke, Gong, and Jones (2014). For more information on the UDel data and other global weather data sets, see Dell, Jones, and Olken (2013).

data to match each DHS cluster to the weather grid cell where it is located, and calculate rainfall shocks at the grid cell level. Our main sample matches up to 2,767 unique grid cells across the sub-Saharan African region, each of which is approximately 2,500 square kilometers in area. For India, the lack of GPS coordinate information prevents us from using the same approach. Instead, we use mapping software to intersect the UDel weather grid with a district map for India, and then calculate land-area weighted average rainfall estimates for each district. Of the 675 districts in India, 502 are represented in our main sample, and these districts have a mean area of 5,352 square kilometers.

The existing economic literature uses a wide variety of methodologies to construct measures of relative rainfall shocks. Here, we adapt an approach used by Burke, Gong, and Jones (2014) and define a negative rainfall shock (drought) as calendar year rainfall below the 15th percentile of a location's (grid cell or district) long-run rainfall distribution, and a positive rainfall shock (flood) as calendar year rainfall above the 85th percentile of a location's long-run rainfall distribution. We use a long-run time series (1960-2010) of rainfall observations to fit a gamma distribution of calendar year rainfall for each location (grid cell or district). We then use the estimated gamma distribution for a particular location to assign each calendar year rainfall realization to its corresponding percentile in the distribution. Our drought and food variables are constructed for each calendar year, and are then merged into the person-period marriage dataset described in Section 4.

By constructing rainfall shocks in this manner, we address two important requirements needed for the validity of our study: (1) our rainfall shock mea-

sures must have a meaningful economic impact on household incomes; and (2) the shock measures must be orthogonal to other factors that also affect marriage decisions, such as the general level of poverty in an area, or other features such as access to schooling and economic opportunities for young women. The first condition is essential to ensuring that rainfall shocks are an appropriate proxy for local economic conditions, while the second condition limits concerns about a spurious relationship between weather shocks and the early marriage hazard. By looking at extreme rainfall realizations relative to what is normally experienced in a location, we increase the likelihood that both conditions are met. To provide further confidence that we have satisfied the first condition, we next investigate the relationship between our constructed rainfall shock measures and agricultural yields in Africa and India

3.2.1 Weather shocks and crop yields

In this paper, we assume that rainfall shocks affect household income in rural areas through their impact on crop yields. While the relationship between weather shocks and agricultural output is well established in the literature (see for example, Jayachandran (2006); Schlenker and Lobell (2010); Shah and Steinberg (forthcoming); Burke, Gong, and Jones (2014)), in this section we explore how our constructed measure of rainfall shocks affects aggregate crop yields in Africa and India.

For Africa, we estimate the impact of rainfall shocks on production of maize (the most important staple crop on the sub-continent) and cereals (which includes maize, wheat, barley, rye, and rice paddy). Yield data are

available annually for each country in sub-Saharan Africa over the period 1960-2010 from the FAOStat database. Since we have country-level yield data, we construct measures of country-level rainfall shocks (drought and food) in the same manner used in the main analysis.

[Insert Table II and Figure II]

As shown in Table II, drought (rainfall below the 15th percentile) reduces maize and cereals yields by 8.8% and 10.2%, respectively, in the countries included in our main analysis ("DHS sample"). Flood (rainfall above the 85th percentile) is estimated to improve maize and cereal yields by 5.3% and 5.7%, respectively, although the former estimate is not significantly different from zero. We also estimate a local linear regression of the relationship between rainfall percentile and cereal yields, the results of which are shown in Figure II. Abnormally low rainfall clearly leads to reduced cereal yields, but abnormally high rainfall seems to have a non-linear relationship (more rainfall is good up to a point, and then it starts to have a negative impact on yields).

[Insert Table III and Figure III]

For India, we rely on district-level yield data from the World Bank India Agriculture and Climate Data set. We look at the impact of rainfall shocks (constructed at the district-level) on yields of the five most important crops in the country (rice, wheat, bajra, jowar, and maize), as well as a revenue-weighted average of all five. As shown in Table III, drought negatively affects yields of all crops, and is estimated to reduce yields by 9.1% overall. Flood,

on the other hand, has positive effects for rice yields and negative effects for other staples, resulting in a null impact on yields overall. This finding is supported by the local linear regression results in Figure III. The fact that food has no real positive or negative impact on yields helps explain the fact that, in our main analysis, food has no measurable impact on the marriage hazard.

From this analysis, we conclude that our drought measure serves as an appropriate proxy for a negative income shock in both regions. Flood does not seem to be a strong proxy for a positive income shock in either region. With regard to the second condition, a major concern with our empirical strategy is that our constructed weather shocks are correlated with the underlying climatological conditions of a particular location, which in turn could have important impacts on local infrastructure and/or general poverty levels. This concern is alleviated by the fact that, by definition, every location in our data has the same likelihood of experiencing a rainfall shock in a given year, regardless of the underlying climatological conditions, meaning that our measures of drought and food should be orthogonal to the unobservable characteristics of a local area. Appendix figure C1 provides evidence to substantiate the claim that our rainfall shock measures are orthogonal to long-run rainfall trends, as well as other relevant characteristics of local areas, thus limiting the concern of a spurious relationship driving our results.

4 Empirical Strategy

To examine the impact of weather shocks on the incidence of early marriage, we estimate a linear approximation of a discrete-time hazard (duration) model.[12] The duration of interest is the time between t_0, the age when a woman is first at risk of getting married, and t_m, the age when she enters her first marriage. In our analysis, t_0 is assumed to be age 10, which is the minimum age at which a non-negligible number of women in our sample report getting married for the first time.

In order to estimate the model, we first convert our data into person-year format. A woman who is married at age t_m is treated as if she contributed $(t_m - t_0 + 1)$ observations to the sample: one observation for each at-risk year until she is married, after which she exits the data. The dependent variable, $M_{i,k,t}$ is a binary variable coded as 1 in the year a woman gets married, and zero otherwise. Each time-invariant covariate is repeated for every period, and time-varying covariates (the weather shocks) are updated each period. Since we are interested in early marriage, in most regressions we only include data on women through age 17. Thus, women married after age 17 are right censored.[13]

We use the person-year data to estimate the probability of woman i living in location k (grid cell in Africa, district in India) entering her first marriage at age t:

[12] This approach is adopted from Currie and Neidell (2005), who use a similar set-up to investigate the impact of pollution exposure on infant mortality.

[13] For example, a woman who is married at age 16 would appear seven times in the data, and her marriage vector would be $(M_{i,k,10,...,}Mi,k,15,Mi,k,16) = (0,...,0...,1)$. A woman who is not married by age 17 appears in the data eight times, and her marriage vector is a string of zeroes.

$$M_{i,k,t} = \alpha(t) + Z_i'\gamma + X_{k,t}'\beta + \omega_k + \epsilon_{i,k,t}.$$

In this equation, $\alpha(t)$ reflects the baseline hazard into marriage, Z_i are time-invariant female characteristics, and $X_{k,t}$ are time-varying measures of weather conditions in location k during the year in which the woman is age t. In the Africa sample, location (the k) refers to the grid cell location of woman i, whereas in the India sample, area refers to the administrative district of residence of woman i. We include location-specific fixed effects, ω_k, to control for time-invariant unobservables.[14]

We specify the baseline hazard in the most flexible way possible, with indicators for each age (i.e. $\alpha(t)$=$\alpha_{11}D_{11}$+...+$\alpha_{17}D_{17}$). The main coefficients of interest are included in β, the coefficients that measure the effect of rainfall shocks on the probability of marriage. The time-invariant female characteristics we include in $Z_i$are birth cohort fixed effects (1950s, 1960s, etc.) as well as an indicator for whether a woman ever attended formal schooling.[15] Included in $X_{k,t}'$ are a dummy indicator for a negative rainfall shock (drought) in a given year, and a dummy indicator for a positive rainfall shock (food) in that year. Since we are combining data across multiple survey instruments, we use population-weighted survey weights to make results representative of

[14]As discussed in Section 3, there are 502 districts represented in our main sample for India, with an average geographic area of 5,352 square kilometers and an average of 125 women per district. There ara 2,767 grid cells represented in our main sample for Africa, with an average geographic area of 2,500 square kilometers and an average of 84 women per grid cell.

[15]Schooling decisions are also likely to be affected by weather shocks, which is why we only include a variable capturing whether a woman ever attended school. The decision to ever attend school is likely made when a person is very young (i.e. prior to age 10), so it should be exogenous to weather shocks occurring when a woman is age 10 or older.

the countries included in the analysis. We estimate regressions with standard errors clustered at the grid-cell (for Africa) or district (for India) level, to allow for correlation in error terms across individuals in the same area.

With the inclusion of location (grid cell or district) fixed effects, the impact of weather shocks on the early marriage hazard is identified from within-location variation in weather shocks and marriage outcomes. The key identifying assumption of the analysis is that, within a given location, the weather shocks included in $X_{k,t}$ are orthogonal to potential cofounders. As discussed in Section 3, this should be true given the way these variables were constructed; each area is equally likely to have experienced a shock in any given year, so identifying variation comes from the random timing of the shocks. The exogeneity of rainfall shocks is particularly important in our setting because, given the retrospective nature of our analysis, there are many unobservables for which we cannot control.[16]

In the robustness section, we run placebo tests looking at the impact of future rainfall shocks on marriage outcomes, and show that there is no significant relationship, which should also alleviate concerns about a spurious relationship between weather shocks and early marriage outcomes. Another significant threat to identification comes from the fact that we only have information on where women currently reside, and not on where they resided around the time they were first married. This introduces two potential problems to the analysis. The first problem relates to the custom of patrilocal exogamy discussed in Section 2. Due to patrilocal exogamy, women move

[16]Most importantly, we lack data on parental wealth or poverty status around the time of a woman's marriage, on the educational background of her parents, and on the numbers and ages of her siblings, all of which will affect marital timing decisions (see Vogl, 2013).

away from their natal village at the time of marriage, so that the village they live in at the time of the interview is different than the village where they grew up. Second, even after marriage, the household may have migrated to another village.

We argue that neither of these problems is a major threat to our analysis, for two reasons. First, the available data on patrilocal exogamy practices in India and Africa (summarized in Section 2) imply that while many women leave their natal village at marriage, most do not move very far away, so it is unlikely that have moved out of the geographic area at which we define our rainfall shocks (administrative districts in India, grid cells in Africa). Post-marriage migration is also most likely not an issue, since we focused on women currently residing in rural areas, and rural-rural migration prevalence is low. Second, even if there were large numbers of women currently living far away from their natal home, this wouldn't be an explanation for the results we find. In fact, women currently living far from their natal home should only cause our estimates of the impact of weather shocks on the marriage hazard to be biased toward zero. The DHS and IHDS surveys include some limited information related to marriage migration for the women in our sample, which we use to verify that our results hold for women that never migrate or do not migrate far (and in fact, are larger in magnitude for these women than for the sample as a whole).

A final potential threat to identification comes from measurement error in women's recollections of age and year of marriage. Greater imprecision in women's recollections will lead to greater imprecision in the standard errors of our estimates. However, marriage is arguably one of the most important

events in rural women's lives in these regions, so it seems unlikely that they would be unable to remember when they were married.

5 Results

5.1 Main results

[Insert Table IV]

Table IV displays results of Equation (1), estimated separately on the data for Africa and India. We present results for all women (rural and urban), as well as results for the rural sample only. Drought - a determinant of negative income shock - has opposite effects on the early marriage hazard in the two regions. In Africa, drought increases the hazard into early marriage; in India, drought decreases the hazard. These effects are concentrated among women living in rural areas - effects in urban areas are not statistically different from zero in either region. Focusing exclusively on the rural sample, we find that drought reduces the early marriage hazard by 0.2 percentage points in Africa (Column 3), and increases the early marriage hazard by 0.8 percentage points in India (Column 6). Flood does not have an impact on the marriage hazard in either region, which is not surprising given that we show that our constructed food measure has relatively muted effects on crop yields.

5.2 By prevalence of polygamy in Sub-Saharan Africa

[Insert Table V]

In table V, we show the estimated effects of rainfall shocks separately for countries with high (more than 33%) and low (less than 33%) rates of polygamy.[17] Indeed, the effect of drought on the early marriage hazard appears to be concentrated in countries that have high rates of polygamy (which, for the most part, are all located in West Africa). In the high-polygamy sample, drought is estimated to increase the early marriage hazard by 0.6 percentage points, significant at the 1% level. Given that we find effects to be concentrated in the high polygamy countries, for the remainder of the paper we limit our analysis to this sub-sample.

5.3 By age

The results presented so far estimate the average effect of weather shocks across all ages represented in the data (age 10 to age 17). However, the baseline hazard into marriage varies significantly within this age range, suggesting that the effects of income shocks will also vary. To investigate this possibility, we estimate a version of Equation (1) that interacts weather shocks with indicators for three age categories: Age 10-12, Age 13-14 and Age 15-17. We also estimate a version that censors women after age 22 (rather than after age 17) and includes an additional interaction term between weather shocks and an indicator for ages 18-21.

[Insert table VI]

[17] We define a country as having a high rate of polygamy if the number of ever-married women in the DHS data who are in polygamous unions exceeds 33%. This is roughly the median rate of the sample.

The results of these regressions, presented in Table VI, show that weather shocks have the greatest effects on the marriage hazard for women in their mid-teens (ages 13-17). In India, the interaction terms for the youngest age category (Age 10-12) are not significantly different from zero, which may be due to the fact that a large fraction of girls in this age group has not begun menstruation, an important biological milestone after which marriage hazards increase (see Field and Ambrus (2008)). It is worth noting that the hazard into early marriage is very low for this sub-sample (less than 1%), so it may be the case that marriage for this sub-sample is a very different phenomenon from marriage of girls at other ages.

Figure IV provides a graphical representation of the results presented in columns (2) and (4) of Table VI (i.e. using the data up until age 21). The results for Africa indicate that girls living in high-polygamy countries that experience drought between the ages of 13-17 are about 14%-15% more likely to get married than girls that do not experience drought. For non-Northern states in India, the results indicate that girls that experience a drought between ages 15-17 are nearly 13% less likely to get married. This figure is restricted to the sample of high polygamy countries for Africa and northern states for India, where dowry is widespread.

5.4 Birth cohort and changes in the effects of rainfall shocks over time

[Insert Table VII]

The final question we attempt to understand is whether the effects of

rainfall shocks are consistent across birth cohorts. According to Columns (2) and (4) of Table VII, the effects of weather shocks on the hazard into early marriage are more muted in more recent birth cohorts (and in fact, are not significantly different from zero). It is not clear why this is the case: due to climate change, weather variability is actually increasing on both continents. It may be that modernization provided households with a larger toolbox of coping mechanisms (such as rural-urban migration, particularly of male household members). Increases in access to schooling for girls, or general changes in parental views on ideal age at first marriage, may also be playing a role.

6 Robustness

In this section, we present a set of robustness checks to show that: (1) results are robust to different specifications and different measures of weather shocks; and (2) results are not being driven by a spurious relationship between the rainfall shock measures and other unobservables that also affect the marriage hazard. We also present results that address the concerns related to women's change in residence between the time of marriage and the time of interview.

Robustness of results to alternative specifications and samples

[Insert table VIII]

The first robustness check we perform is to confirm that our results are not sensitive to alternative specifications or cutoffs of data. Table VIII presents results that: (1) remove individual level controls (birth cohort indicators and

educational status); (2) remove the survey weights; and (3) use only one (the most recent) survey for each country. Across all three alternate specifications, the main findings are stable: drought has a positive effect on the marriage hazard.

Placebo test - impact of future shocks on marriage hazard

[Insert table IX]

The second robustness check we perform is a placebo test to verify that our results are not being driven by omitted variables that are (a) correlated with our weather shocks and (b) also factors that affect the marriage hazard. In order to do this, we run placebo regressions that test whether future weather shocks - that is, shocks that occur in period $t + s$, for $s > 0$ - have any effect on the marriage hazard at age t. If our results are being driven by correlation between weather shocks and time invariant local area characteristics, then these placebo regressions will yield statistically significant results. However, if we are capturing a true relationship between drought and marriage rates, then future shocks should have no impact on the marriage hazard. In Table IX, we present the results of these placebo tests, using measures of drought and food 1 to 5 years in the future. In nearly all cases in these placebo regressions, results are not significantly different from zero.

Alternative measures of weather shocks

[Insert Figure V and Table X]

As a third robustness check, we investigate how the impact of drought varies with the severity of our drought measure. We use two approaches.

First, we re-estimate Equation (1) for varying cutoff levels to determine drought, ranging from the 5th percentile to the 45th percentile. Figure V plots the estimated coefficients for different cutoff percentiles for drought, along with 95% confidence intervals. In both regions, the point estimate is fairly stable around the default 15th percentile cutoff, and as definition of shock becomes more severe, the estimated impact increases. One interesting difference between the two sets of results is that, in Africa, the estimated impact of drought trends to zero as the cutoff approaches the 20th percentile mark, while in India the results stay significant through the 40th percentile.

To gain greater insight into whether more severe drought yields more significant impacts not the marriage hazard, we estimate Equation (1) with indicators for rainfall distribution quintiles (below 20th percentile, 20th-40th percentile, etc.). These results are in Table X. As expected, the largest magnitude effects are found for the most extreme rainfall shocks (in the bottom 20th percentile of the rainfall distribution).

Testing identification assumption on district of residence

Finally, we use what data are available to investigate how effects vary by pattern of marriage migration. As noted in Section 2, the DHS surveys ask women how long they have lived in their current village of residence. We can use this information to look at whether the estimated impacts of rainfall shocks are stronger for women that we know lived in their current place of residence for the period under investigation. To do this, we construct a indicator for whether a woman was born in her current village or city, and interact this with our rainfall shocks.

[Insert tables XI and XII]

As shown in Table XI, drought has a larger impact for women who were born in their current location (the difference is significant at the 10% level). One important caveat to keep in mind is that this is an endogenous variable that may be closely related to other factors affecting the marriage hazard. In fact, women in the "born here" group are more likely to be uneducated and have a lower mean age of marriage than women that have migrated from their natal village. Although we include the control for whether a woman has ever attended formal schooling, unobservable differences between women that have and have not migrated from their natal home may still exist, and these unobservable may be contributing to the larger impact of drought for the "born here" group. Results are significant even for women that are not living in their natal village, supporting the identifying assumption that even women that migrate at marriage were still living with the same grid cell that they do at the time of the survey (and were thus exposed to the same shocks).

Nearly all Indian women leave their natal village at the time of marriage, so it is not instructive to carry out the same analysis on the India sample. Instead, we use the information on marriage migration distance in the IHDS to see whether the estimated effects are stronger for women that did not move as far from their natal home. We divide the sample at the median reported distance from natal home (2 hours), and estimate heterogenous effects for the two groups. As shown in Table XII, the effect of drought is higher for women that still live within 2 hours of their natal home. The estimated effect of drought for women living further than 2 hours from their natal home is not significantly different from zero. Along a large number of observables, women that move further than 2 hours from their natal home at marriage are very

similar to women that stay close to home, suggesting that the differential effect has more to do with the fact that women that currently live far from their natal home are more likely to live in a different district than where they were born.

7 Conclusion

This paper presents empirical results showing that negative weather shocks (which proxy for aggregate negative income shocks in rural areas) have opposite effects in Africa and India. In Africa, drought leads to an increase in the early marriage hazard, while in India, drought leads to a decrease in the early marriage hazard. These findings are informative for policy aimed at reducing the prevalence of child marriage in the developing world for two reasons. First, they provide evidence that marital timing decisions are indeed shaped by economic conditions. Second, they underscore the important interdependencies between prevailing cultural institutions and household responses to economic hardship, which suggests that policies are more likely to be effective if they are tailored to the local context (Ashraf, Bau, Nunn, and Voena, 2015).

The analysis in this paper suggests that the effects of positive and negative weather shocks on the hazard into early marriage have become more muted over time. Explaining why these effects have become less pronounced is out of the scope of the current paper, but possible reasons include: increased economic and educational opportunities for women, changes in social norms, and increased tools available to households to buffer against negative income

shocks. Further exploration in this area could provide useful insights for designing effective policies aimed at combating early marriage.

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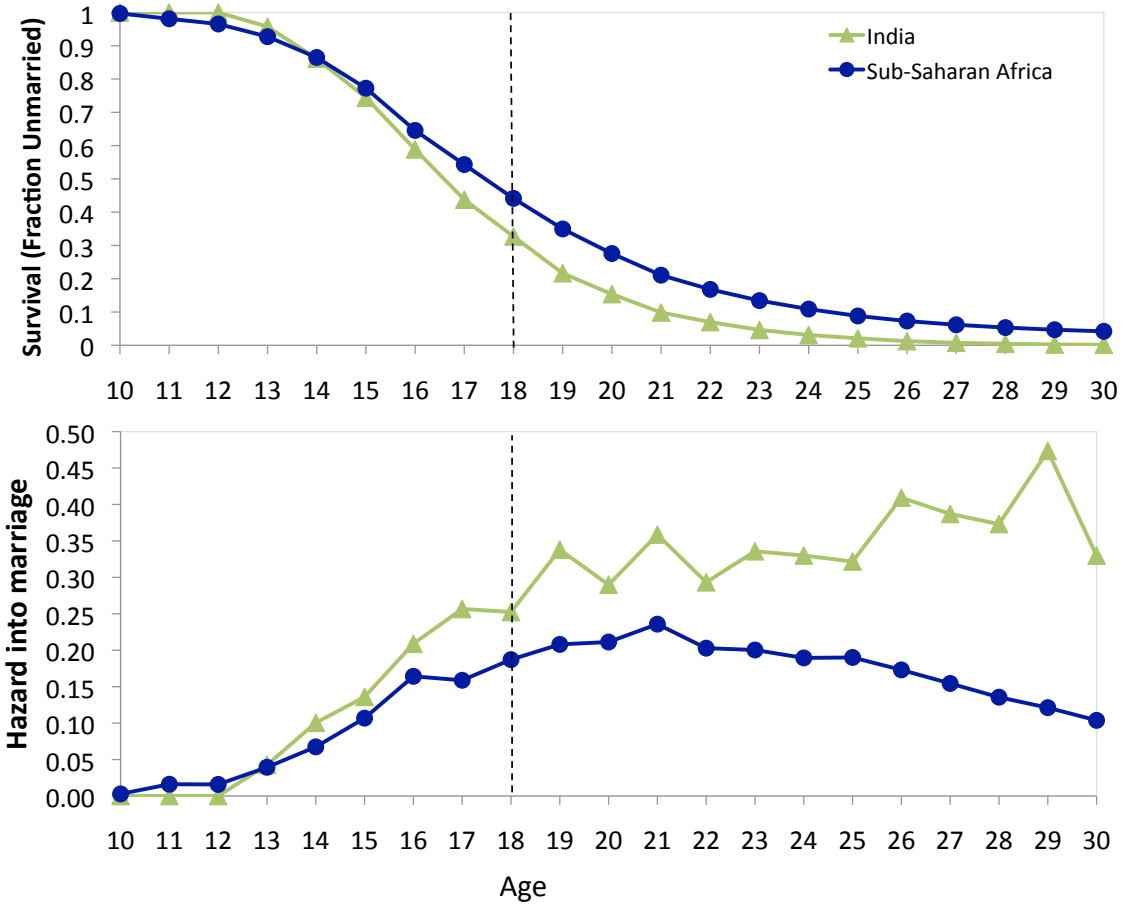
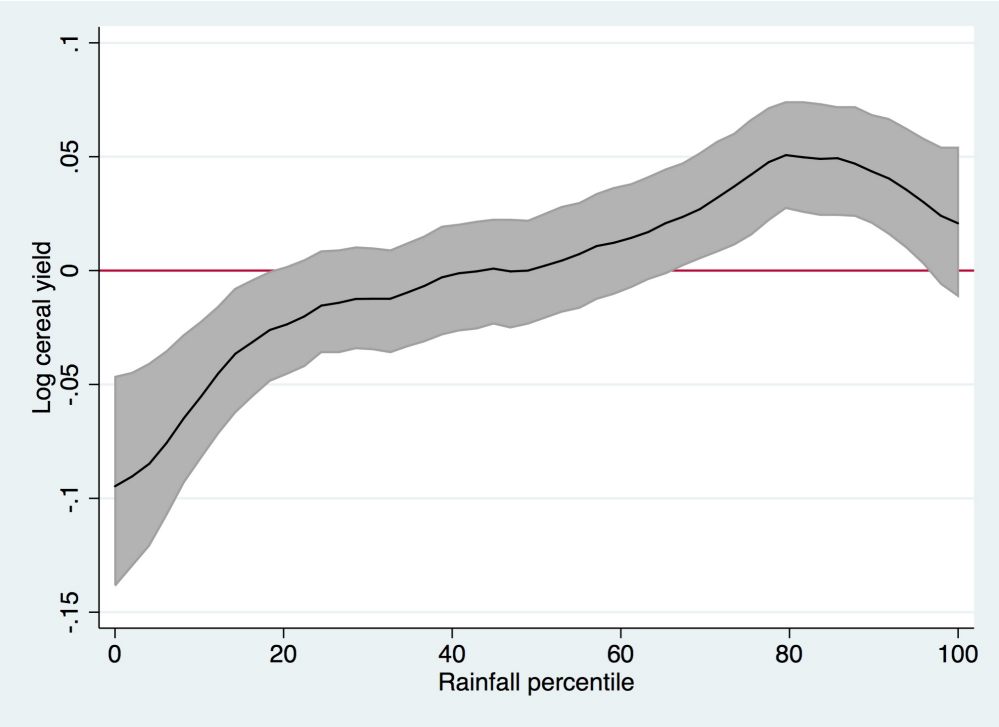
Figure I: Hazard and survival into marriage for main sample used in analysis



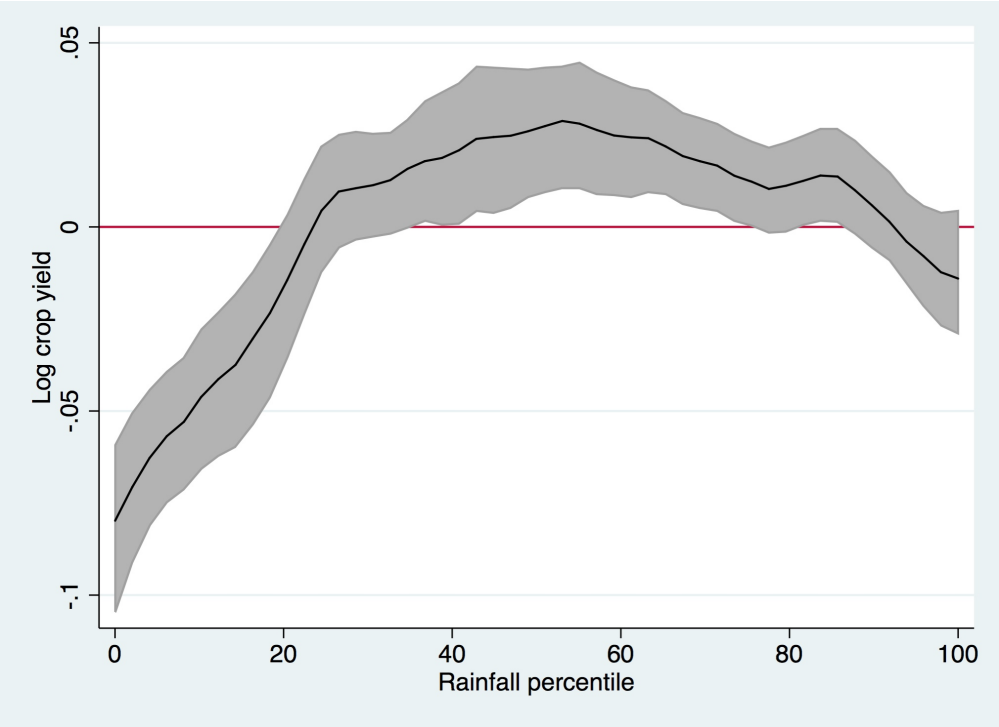
Notes: Includes women aged 25+ at the time of survey living in rural areas.

Figure II: Weather shocks and cereal yields in Sub-Saharan Africa
Local linear regression



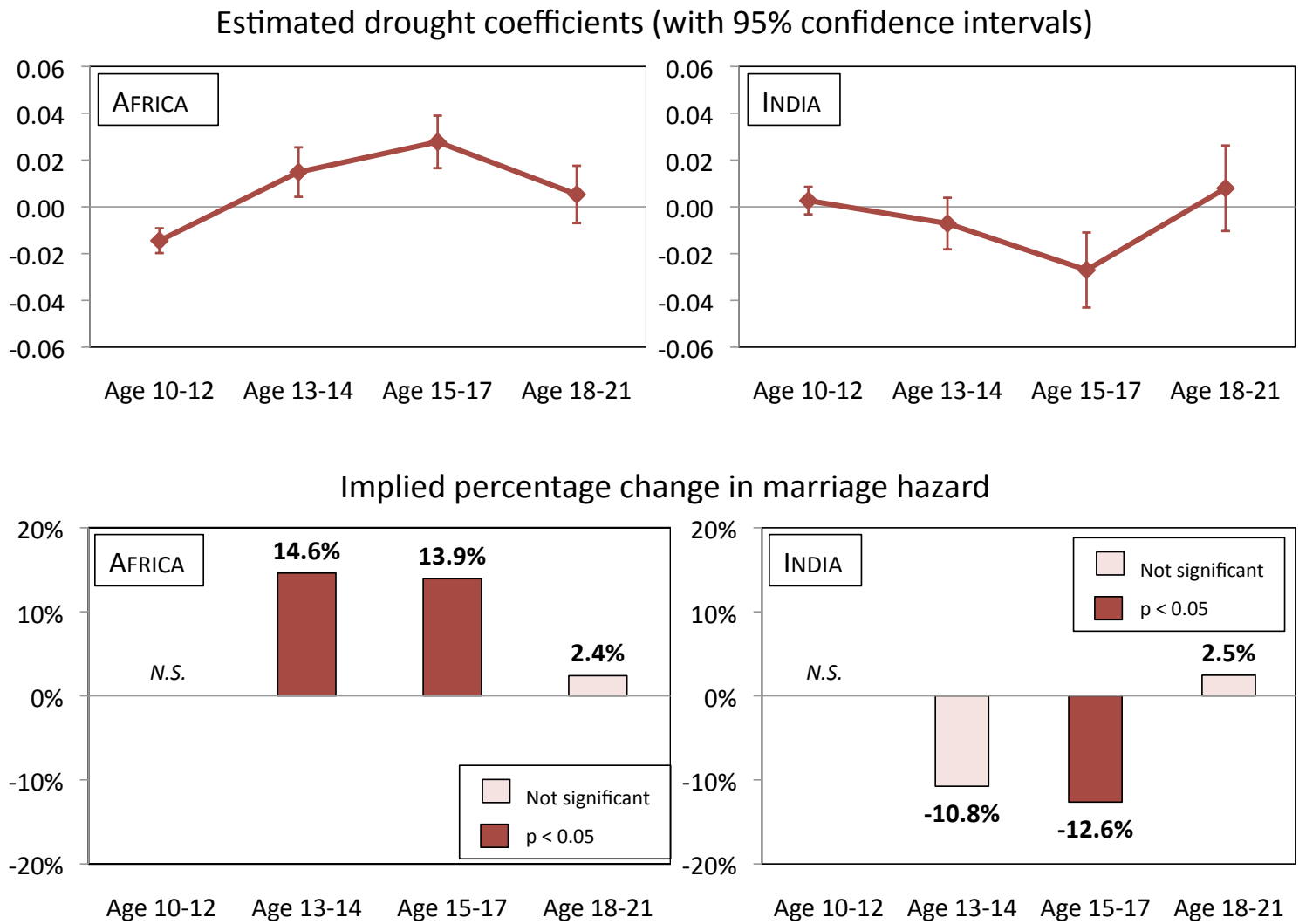
Notes: Dependent variable is the log of annual cereal yield (hectograms per hectare) for each included country, from 1960-2010. Yield data are from FAOStat. Included countries are the 30 countries in the main analysis ("DHS" sample). The line represents results from a local linear regression of crop yield on rainfall percentile, after controlling for country- and year- fixed effects. 95% confidence interval is shaded in grey.

Figure III: Weather shocks and crop yields in India
Local linear regression



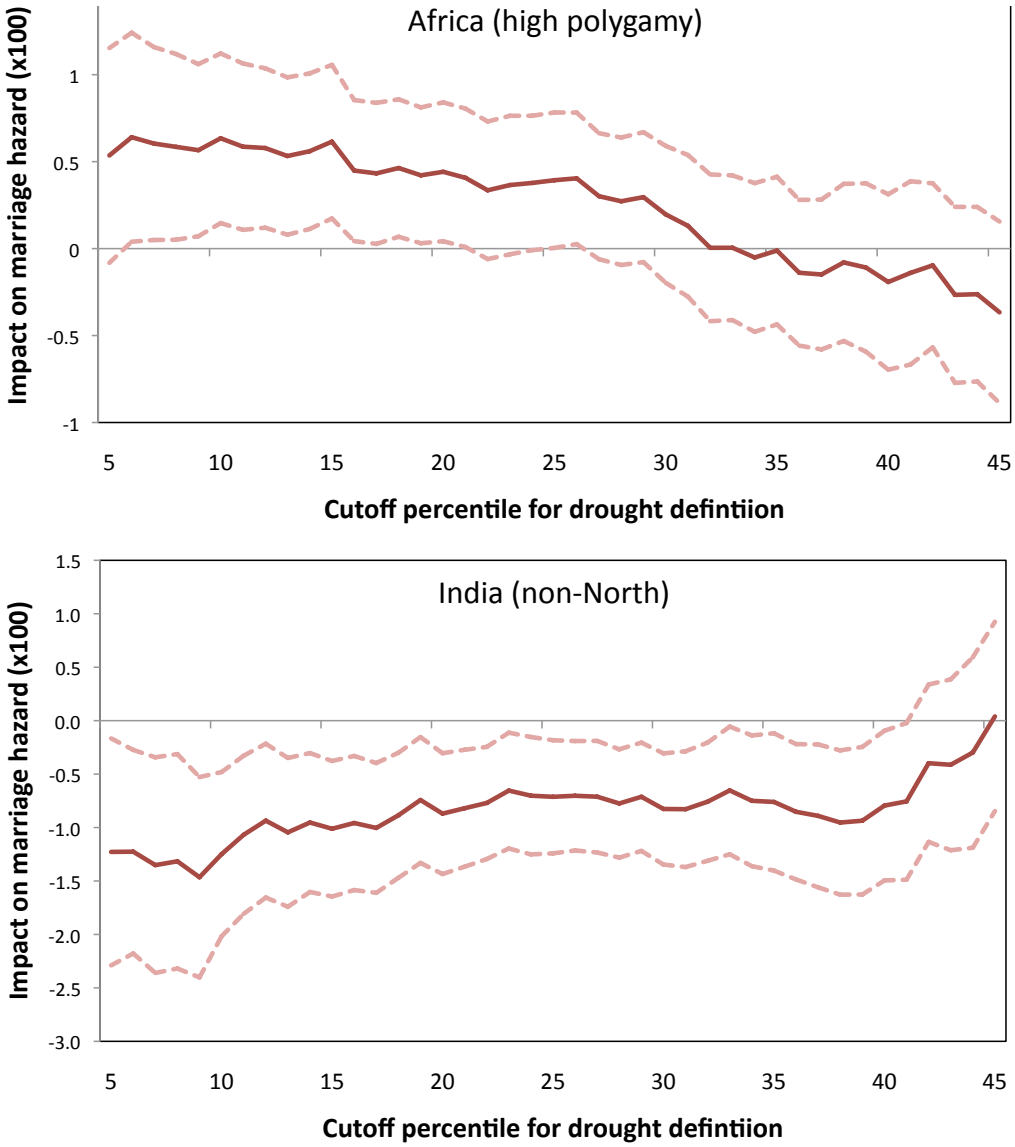
Notes: Dependent variable is the weighted average log yield (tons per hectare) for the five major crops by revenue for each district, from 1957-1987. Yield data are from the World Bank India Agriculture and Climate Data set. The line represents results from a local linear regression of crop yield on rainfall percentile, after controlling for district- and year-fixed effects. 95% confidence interval is shaded in grey.

Figure IV: Effect of negative rainfall shocks at different ages



Notes: Sample is high-polygamy countries in Africa, non-Northern states in India. The top panel panel plots the estimated coefficients from columns (2) and (4) of Table VI, with 95% confidence intervals. The bottom panel shows the implied change in the marriage hazard (average over all ages in each category). "N.S." = not shown. we don't show the implied percentage change in the marriage hazard for age 10-12 group because it is off the scale of the chart; the implied change for Africa is -400% and the implied change for India is 78%.

Figure V: Robustness to different percentile cutoffs for rainfall shocks



Notes: Each panel presents the coefficient point estimates of the impact of a particular definition of drought on the early marriage hazard for the rural sample in each region (high-polygamy sample in Africa; non-Northern states for India). The African data includes countries with high polygamy rates (33% or higher) only. The dotted lines represent the 95% confidence intervals.

Table I: Summary statistics on main sample used in analysis

	India	Africa
Mean age at first marriage		
Full sample	16.50	17.38
By birth cohort:		
1950s	16.33	16.98
1960s	16.48	17.43
1970s	16.55	17.46
1980s	16.83	17.37
% change, 1950s to 1980s	3.1%	2.2%
By education status:		
No schooling	15.62	16.44
Some schooling	17.70	18.58
Early marriage prevalence		
Full sample	66.4%	56.3%
By birth cohort:		
1950s	69.2%	64.2%
1960s	67.0%	57.9%
1970s	64.5%	54.4%
1980s	63.1%	52.0%
% change, 1950s to 1980s	-8.8%	-18.9%
By education status:		
No schooling	76.7%	67.5%
Some schooling	50.6%	41.9%
Age gap (years)		
Full sample	6.16	8.79
By early marriage status:		
Marry before age 18	6.56	9.76
Marry after age 18	5.32	7.61

Figures are for the main sample used in the analysis: rural women, aged 25+ at time of interview, born in 1950 or later. Statistics are weighted to be representative of the included countries.

Table II: Weather shocks and crop yields in Sub-Saharan Africa

	(1)	(2)	(3)	(4)
Crop:	Maize	Maize	Cereals	Cereals
Countries:	All SSA	DHS	All SSA	DHS
Drought	-0.117***	-0.120***	-0.120***	-0.110***
	(0.027)	(0.028)	(0.025)	(0.026)
Flood	0.039	0.050	0.041**	0.037
	(0.028)	(0.030)	(0.019)	(0.024)
N	1850	1450	1818	1450
R^2	0.590	0.518	0.751	0.755

Dependent variable is the log of annual yield (hectograms per hectare) for each included country, from 1960-2010. Yield data are from FAOStat. "All SSA" columns include all Sub-Saharan African countries in the FAOStat database, and "DHS" columns include the 30 countries in the main analysis. Regressions include year and country fixed effects. Standard errors, clustered at the country level, are reported in parentheses.
*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table III: Weather shocks and crop yields in India

	(1)	(2)	(3)	(4)	(5)	(6)
Crop:	Rice	Wheat	Bajra	Jowar	Maize	All (avg)
Drought	-0.179***	-0.047***	-0.215***	-0.197***	-0.051***	-0.091***
	(0.019)	(0.014)	(0.026)	(0.022)	(0.018)	(0.015)
Flood	0.060***	-0.000	-0.051**	-0.072***	-0.136***	-0.015
	(0.010)	(0.011)	(0.021)	(0.017)	(0.018)	(0.012)
N	7,182	6,730	5,276	6,214	6,720	7,517
R^2	0.684	0.704	0.594	0.615	0.399	0.592

Dependent variable is the log of annual yield (tons per hectare) for each district, from 1957-1987. Yield data are from the World Bank India Agriculture and Climate Data set. The "All (avg)" column presents results for the weighted average log yield for the five major crops by revenue. Regressions include year and district fixed effects. Standard errors, clustered at the district level, are reported in parentheses.
*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table IV: Effect of shocks on early marriage hazard, full sample

	Africa			India		
	All	All	Rural	All	All	Rural
	(1)	(2)	(3)	(4)	(5)	(6)
Drought	0.002*	0.003**	0.002**	-0.005***	-0.008***	-0.008***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)
Flood	-0.002	-0.002	-0.002	0.000	0.002	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)
Drought * Urban		-0.002			0.007**	
		(0.003)			(0.003)	
Flood * Urban		0.002			-0.004	
		(0.002)			(0.004)	
Linear combinations:						
Drought + Drought * Urban		0.0003			-0.001	
		(0.002)			(0.002)	
Flood + Flood * Urban		-0.0001			-0.003	
		(0.002)			(0.002)	
Person-year observations	2,384,123	2,384,123	1,631,297	535,400	535,400	333,642
Women	337,955	337,955	234,839	96,869	96,869	62,859
R^2	0.084	0.084	0.091	0.105	0.105	0.113

Estimated using OLS; sample includes person-year observations up to age 17 for each woman. Specifications include indicator variables for: age, decade of birth, urban/rural designation (where applicable), and whether a woman ever attended school. Specifications also include fixed effects at the grid cell level for Africa, and at the district level for India. Results are weighted to be representative of the included countries. Standard errors are clustered by grid cell for Africa, and by district for India.
*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table V: Effect of shocks by prevalence of polygamy, sub-Saharan Africa

	Africa	
	(1)	(2)
Countries:	All	High Polygamy
Drought	0.0003	0.006***
	(0.001)	(0.002)
Flood	-0.001	-0.004
	(0.001)	(0.003)
Drought * High Polygamy	0.005**	
	(0.003)	
Flood * High Polygamy	-0.002	
	(0.003)	
Linear combinations:		
Drought + Drought*High Polygamy	0.006***	
	(0.002)	
Flood + Flood*High Polygamy	-0.003	
	(0.003)	
Person-year observations	1,631,297	663,220
Women	234,839	98,977
R^2	0.091	0.102

High polygamy: polygamy rates higher than 33%. Estimated using OLS. Rural sample only; includes person-year observations up to age 17 for each woman. Specifications include indicator variables for: age, decade of birth, and whether a woman ever attended school. Specifications also include fixed effects at the grid cell level. Results are weighted to be representative of the included countries. Standard errors clustered by grid cell.
*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table VI: Effect of shocks by age

	Africa (high-polygamy)		India (non-North regions)	
	Age < 18	Age < 26	Age < 18	Age < 26
	(1)	(2)	(3)	(4)
Drought - Age ≤ 12	-0.013***	-0.014***	0.002	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Drought - Age 13-14	0.017***	0.015***	-0.008	-0.007
	(0.005)	(0.005)	(0.006)	(0.006)
Drought - Age 15-17	0.032***	0.028***	-0.027***	-0.027***
	(0.006)	(0.006)	(0.008)	(0.008)
Drought - Age 18+		0.005		0.021*
		(0.006)		(0.011)
Flood - Age ≤ 12	-0.004	-0.004	0.002	0.003
	(0.003)	(0.003)	(0.005)	(0.005)
Flood - Age 13-14	-0.005	-0.0002	-0.003	-0.003
	(0.005)	(0.005)	(0.005)	(0.006)
Flood - Age 15-17	-0.002	-0.0002	0.016	0.017
	(0.008)	(0.008)	(0.013)	(0.013)
Flood - Age 18+		-0.007		0.013
		(0.010)		(0.014)
Person-year observations	663,220	769,983	143,742	173,016
Women	98,977	98,977	26,089	26,089
R^2	0.102	0.094	0.112	0.126

Estimated using OLS; sample includes person-year observations up to age 17 for each woman in columns (1) and (3); and person-year observations up to age 21 for each woman in columns (2) and (4). Rural areas only - for Africa, we only include the high polygamy sample, and for India we exclude North Indian states. Specifications include indicator variables for: age, decade of birth, and whether a woman ever attended school. Specifications also include fixed effects at the grid cell level for Africa, and at the district level for India. Results are weighted to be representative of the included countries. Standard errors are clustered by grid cell for Africa, and by district for India. *** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table VII: Heterogeneous effects of rainfall shocks by birth cohort

	Africa (high polygamy)	India (non-North)
	(1)	(2)
Drought	0.009***	-0.013**
	(0.003)	(0.005)
Flood	-0.004	0.004
	(0.004)	(0.008)
Drought*Born in 70s or 80s	-0.005	0.007
	(0.004)	(0.006)
Flood*Born in 70s or 80s	-0.0004	0.002
	(0.005)	(0.010)
Linear combinations:		
Drought + Drought*Born in 70s or 80s	0.004	-0.003
	(0.003)	(0.004)
Flood + Flood*Born in 70s or 80s	-0.004	0.000
	(0.004)	(0.004)
Person-year observations	663,220	143,742
Women	98,977	26,089
R^2	0.102	0.111

Estimated using OLS; sample includes person-year observations up to age 17 for each woman. Specifications include indicator variables for: age, decade of birth, urban/rural designation (where applicable), and whether a woman ever attended school. Specifications also include fixed effects at the grid cell level for Africa, and at the district level for India. Results are weighted to be representative of the included countries. Standard errors are clustered by grid cell for Africa, and by district for India.

*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table VIII: Robustness to specifications and sample

	Africa (high polygamy)			India (non-North)		
	No controls	No survey weights	One survey per country	No controls	No survey weights	One survey per country
	(1)	(2)	(3)	(4)	(5)	(6)
Drought	0.005**	0.004***	0.007***	-0.010***	-0.006***	-0.011**
	(0.002)	(0.001)	(0.002)	(0.003)	(0.002)	(0.004)
Flood	-0.003	-0.001	0.003	0.004	-0.001	0.009
	(0.003)	(0.001)	(0.003)	(0.005)	(0.003)	(0.007)
N	663,220	663,220	322,019	143,949	143,949	61,731
R^2	0.099	0.104	0.096	0.104	0.102	0.121

Estimated using OLS. Specifications include dummy variables for age, decadal birth cohorts, and an indicator for whether a woman ever attended school. Specifications also include fixed effects at the grid cell level for Africa, and at the district level for India. Estimations are weighted to be representative of the included countries. Standard errors are clustered by grid cell for Africa, and by district for India.

*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table IX: Placebo test - Impact of future shocks on early marriage

	(1)	(2)	(3)	(4)	(5)
Shocks at time:	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$
Panel A: SSA					
Drought	0.001	0.001	-0.001	-0.002*	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Flood	-0.001	0.000	0.000	-0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Person-year observations	1,631,297	1,631,297	1,631,297	1,631,297	1,631,297
Women	234,839	234,839	234,839	234,839	234,839
R^2	0.091	0.091	0.091	0.091	0.091
Panel B: India (non-North)					
Drought	0.001	0.003	0.007	-0.006	0.004
	(0.004)	(0.003)	(0.007)	(0.004)	(0.004)
Flood	-0.005	-0.000	-0.004	-0.009**	0.007**
	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)
Person-year observations	143,742	143,742	143,742	143,742	143,742
Women	26,089	26,089	26,089	26,089	26,089
R^2	0.111	0.111	0.111	0.111	0.111

Estimated using OLS. Specifications include dummy variables for age, decadal birth cohorts, and an indicator for whether a woman ever attended school. Specifications also include fixed effects at the grid cell level for Africa, and at the district level for India. Estimations are weighted to be representative of the included countries. Standard errors are clustered by grid cell for Africa, and by district for India.

*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table X: Effect of rainfall shocks, by quintile

	(1) Africa (high-polygamy)	(2) India (non-North)
Bottom Quintile	0.007**	-0.015**
	(0.003)	(0.006)
Second Quintile	0.001	-0.010*
	(0.003)	(0.005)
Third Quintile	0.006*	-0.004
	(0.004)	(0.004)
Fourth Quintile	0.001	-0.004
	(0.002)	(0.006)
Highest Quintile	-	-
Observations	663,220	143,742
R^2	0.102	0.111

Estimated using OLS. Rural sample only. The sample includes person-year observations up to age 17 for each woman. Specifications include indicator variables for: age, decade of birth, and whether a woman ever attended school. Specifications also include fixed effects at the district level, and survey weights. Standard errors are clustered by district.
*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table XI: Effect of rainfall shocks by migration status - Africa, high-polygamy sample

	(1) All	(2) Born here	(3) Not born here
Drought	0.005*	0.009**	0.006**
	(0.003)	(0.004)	(0.003)
Flood	-0.006*	-0.004	-0.004
	(0.003)	(0.004)	(0.003)
Drought * Born Here	0.008*		
	(0.004)		
Flood * Born Here	0.004		
	(0.004)		
Linear combination:			
Drought + Drought * Born Here	0.012***		
	(0.003)		
Flood + Flood * Born Here	-0.002		
	(0.004)		
Person-year observations	697,050	282,133	414,917
Women	102,829	42,033	60,796
R^2	0.097	0.106	0.095

Estimated using OLS. Sample is split into women who report living in their birth village at the time of the survey, and women who report living in a different village from their place of birth at the time of the survey. The DHS does not provide information on how far women's current village of residence is from their natal village. The sample includes person-year observations up to age 17 for each woman. Specifications include indicator variables for: age, decade of birth, and whether a woman ever attended school. Specifications also include fixed effects at the grid cell level, and survey weights. Standard errors are clustered by grid cell.
*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table XII: Effect of rainfall shocks by migration status - India, non-North states

	(1) All	(2) Close to natal home	(3) Not close to natal home
Drought	0.003	-0.016***	0.002
	(0.007)	(0.006)	(0.006)
Flood	0.014	0.006	0.016
	(0.012)	(0.009)	(0.012)
Drought * Close	-0.019**		
	(0.009)		
Flood * Close	-0.008		
	(0.015)		
Linear combination:			
Drought + Drought * Close	-0.016		
	(0.006)		
Flood + Flood * Close	0.006		
	(0.009)		
Person-year observations	60,838	41,714	19,124
Women	8,957	6,164	2,793
R^2	0.121	0.125	0.124

Estimated using OLS. Rural sample from IHDS 2005, non-North Indian states. "Close" sample is women who report living within 2 hours of their natal village. The sample includes person-year observations up to age 17 for each woman. Specifications include indicator variables for: age, decade of birth, and whether a woman ever attended school. Specifications also include fixed effects at the district level, and survey weights. Standard errors are clustered by district.
*** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

A Appendix Tables

Table A1: List of Data Sets and Sources

Region/ Country	Data Topic	Source	Year
Sub-Saharan Africa	Marriage	Demographic and Health Survey (DHS)	1994-2012
	Crop Yield	FAOStat database	1960-2010
India	Marriage	Demographic and Health Survey (DHS)	1998-1999
	Marriage	India Human Development Survey (IHDS)	2005
	Marriage	Rural Economic and Demographic Survey (REDS)	1998
	GPS	GADM database of Global Administrative Areas	
	Crop Yield	World Bank India Agriculture and Climate Data Set	1957-1987
	Weather	University of Delaware, Matsuura and Willmott (UDel)	1900-2010
	Population	World Development Indicators (WDI)	1990-2012
	Crop Calendar Maps	Crop Calendar Dataset (University of Wisconsin-Madison)	

Table A2: List of Data Sets Used for DHS Africa

Country	**Waves**
Benin	1996, 2001, 2011-12
Burkina Faso	1993, 1998-99, 2003, 2010
Burundi	2010
Cameroon	1991, 2004, 2011
CAR	1994-95
Congo DR	2007
Cote D'Ivoire	1994, 1998-99, 2011-12
Ethiopia	2000, 2005, 2011
Gabon	2012
Ghana	1993, 1998, 2003, 2008
Guinea	1999, 2005, 2012
Kenya	2003, 2008-09
Lesotho	2004, 2009
Liberia	1986 2007
Madagascar	1997, 2008-09
Malawi	2000, 2004, 2010
Mali	1995-96, 2001, 2006
Mozambique	2011
Namibia	2000, 2006-07
Niger	1992, 1998
Nigeria	1990, 2003, 2008, 2013
Rwanda	2005, 2010
Senegal	1992-93, 1997, 2005, 2010-11
Sierra Leone	2008
Swaziland	2006-07
Tanzania	1999, 2010
Togo	1988 1998
Uganda	2000-01, 2006, 2011
Zambia	2007
Zimbabwe	1999, 2005-06, 2010-11

Table A3: Traditional Marriage Customs in Sub-Saharan Africa and India

Sub-Saharan Africa		India	
Country	% bride price	Region	% dowry
Benin	90.60%	Andaman/Nicobar-Isl.	0.00%
Burkina Faso	82.70%	Andhra-Pradesh	96.15%
Burundi	99.30%	Assam	2.09%
Cameroon	93.00%	Bihar	9.56%
CAR	64.90%	Dadra/Nagar-Haveli	0.00%
Congo	98.40%	Dehli	18.92%
Cote d'Ivoire	69.00%	Goa/Daman/Diu	11.16%
Ethiopia	66.20%	Gujarat	2.62%
Gabon	74.20%	Himachal-Pradesh	0.00%
Ghana	94.40%	Jammu/Kashmir	37.71%
Guinea	94.50%	Kerala	3.19%
Kenya	100.00%	Laccadive/Minic./Amind.	0.00%
Lesotho	100.00%	Madhya-Pradesh	11.37%
Liberia	97.70%	Madras	95.20%
Malawi	15.33%	Maharashtra	85.80%
Mali	92.60%	Manipur	71.45%
Mozambique	43.50%	Mysore	28.78%
Namibia	58.00%	Nagaland	0.00%
Niger	99.90%	Orissa	81.34%
Nigeria	91.38%	Pondicherry	94.22%
Rwanda	99.70%	Punjab	42.76%
Senegal	98.30%	Rajasthan	57.52%
Sierra Leone	99.20%	Sikkim	77.33%
Swaziland	96.60%	Tripura	0.00%
Tanzania	81.38%	Uttar-Pradesh	11.48%
Togo	62.20%	West-Bengal	4.53%
Uganda	97.10%		
Zambia	19.03%		
Zimbabwe	87.10%		

Notes: Data from Ethnomaps (available at `http://www.ethnomaps.ch/hpm-e/atlas-e.html`, accessed February 7, 2016).

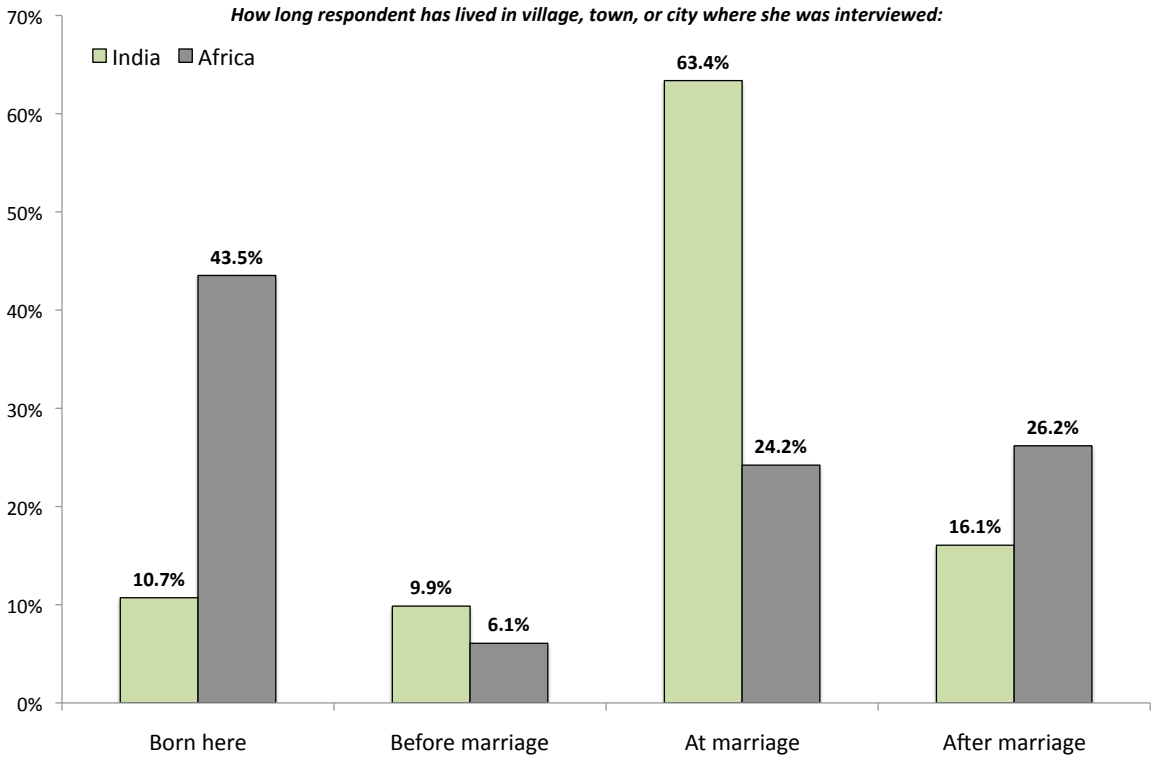
B Marriage migration in Africa and India

Table B1: Patrilocal exogamy and rural-rural migration, India

	India	North	Rest of India
Panel A: Data from DHS-98			
Fraction women - here since birth			
Mean	0.10	0.05	0.15
N	62,248	39,674	22,574
Panel B: Data from IHDS-05			
Distance to wife's natal home (hrs)			
Mean	3.1	3.6	2.7
Median	2.0	3.0	2.0
75th percentile	3.0	4.0	3.0
90th percentile	5.0	6.0	5.0
N	33,497	15,247	18,250
Panel C: Data from REDS-99			
Fraction of heads - here since birth			
Mean	0.98	0.99	0.97
Distance to wife's natal home (km)			
Mean	29.6	33.8	25.2
Median	18.0	20.0	14.0
75th percentile	35.0	40.0	30.0
90th percentile	60.0	60.0	50.0
N	7,474	3,782	3,692

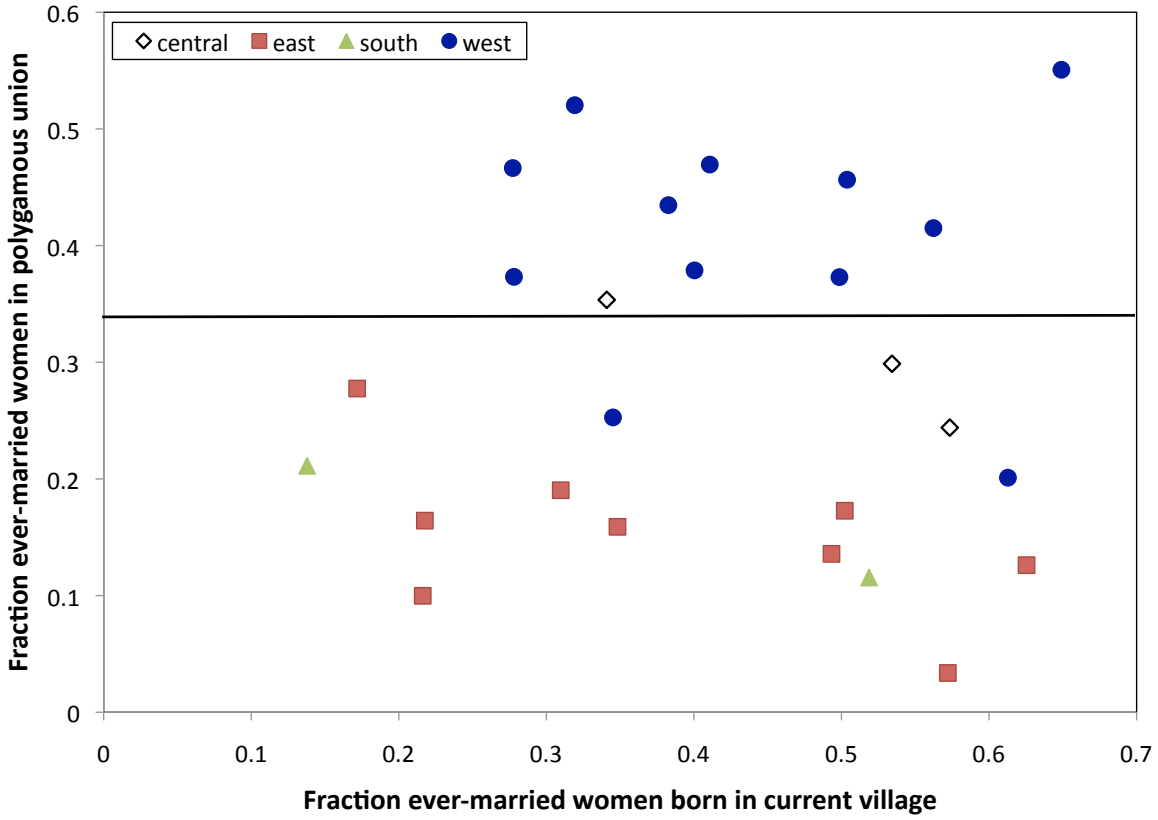
Panel A presents data from 1998 DHS survey for India (ever-married women in rural areas). Panel B presents data from the 2005 IHDS (ever-married women in rural areas). Panel C presents data from the 1999 REDS survey, Deck 8 (information for male-headed households in rural areas).

Figure B1: Migration patterns of ever-married women in rural areas



Notes: The figure shows how long ever-married women in rural areas have lived in their current place of residence (village, town or city where she is interviewed). "Migrated at marriage" includes women who report migrating to their current place of residence within one year of getting married. Data are from the DHS surveys, recodes 3-5.

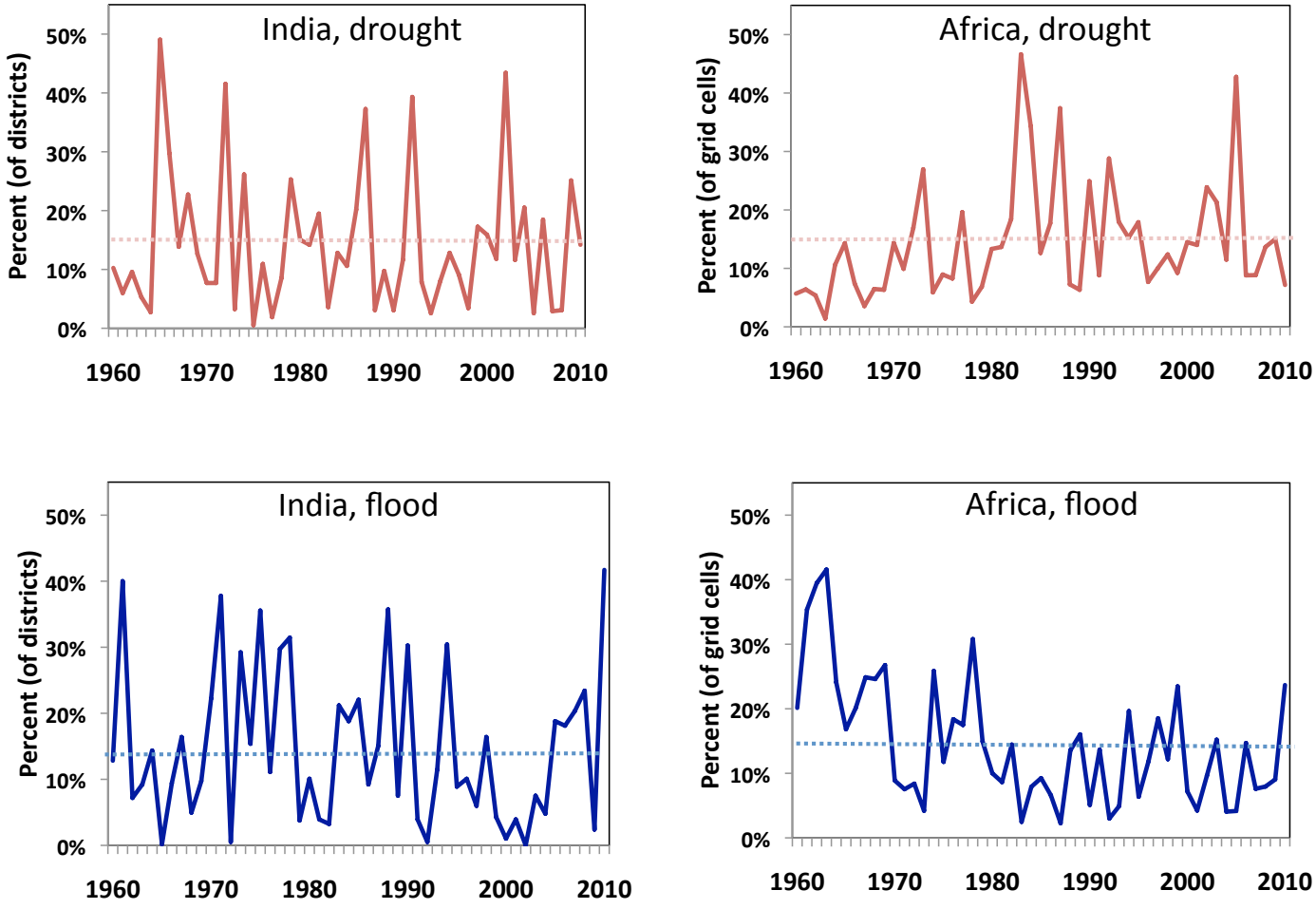
Figure B2: Migration patterns of ever-married women in rural areas



Notes: The figure shows how long ever-married women in rural areas have lived in their current place of residence (village, town or city where she is interviewed). "Migrated at marriage" includes women who report migrating to their current place of residence within one year of getting married. Data are from the DHS surveys, recodes 3-5.

C Orthogonality of weather shocks

Figure C1: Prevalence of weather shocks by year



Notes: The figures present the percent of districts (grid cells) experiencing a rainfall shock in each year in India (Africa). Drought is defined as rainfall in the 15th percentile of the long-run rainfall distribution, and flood is defined as rainfall in the 85th percentile of the long-run rainfall distribution. The dotted lines represent the average prevalence across all years.

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