Rainfall Shocks and Early Marriage in Sub-Saharan Africa and India

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Abstract

In this paper, I examine the impact of variation in local economic conditions on the hazard into early marriage (i.e. prior to age 18) among young women in rural Sub-Saharan Africa and India. I show that rainfall shocks—a major source of income variation in these areas—have opposite effects on the early marriage hazard in the two regions: in Africa, drought increases the hazard into early marriage, while in India, drought decreases the hazard. I argue that the reason for these opposing effects is due to differences in the direction of traditional marriage payments (dowry in India and bride price in Africa). Within the context of formulating policy to prevent early marriage, my results highlight the importance of understanding the interdependencies between prevailing social and cultural norms and household responses to economic hardship; as I show here, differences in prevailing customs can result in dramatically different household responses to aggregate income shocks.

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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. Early 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 female 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.[2] Based on these findings, international development 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.[3]

Successfully reducing early marriage requires understanding the driving forces behind the phenomenon, yet the evidence base in this area is surprisingly weak. 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, I contribute new evidence on one way in which economic constraints and cultural institutions interact to affect the prevalence of early marriage in developing countries. I 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 sub-Saharan Africa and India. I 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. The magnitude of these effects is large, and is concentrated among young women in their mid-teens, the age at which the risk of entering into early marriage is at its highest. In Africa, girls experiencing a drought at age 15-17 are 4.2 percentage points *more* likely to get married the

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

[2]Jensen and Thornton (2003) and World Bank (2014) provide a comprehensive overview of these findings.

[3]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.

following year, a 25.4% increase in the marriage hazard. In India, girls experiencing a drought at this age are 2.0 percentage points *less* likely to get married the following year, a 9.7% decrease in the marriage hazard.

I argue that the reason for the differential impacts across the two regions is 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 sub-Saharan Africa, the custom is for the groom's family to pay a bride price to the bride's family. To show why differences in the direction of marriage payments would cause droughts to have opposite effects on the hazard into early marriage, I set up a conceptual framework of the marriage market where households face aggregate income shocks (rainfall shocks). These shocks have clear predictions for marriage payments: negative shocks lead to reductions in bride price and dowry, while positive shocks lead to increases in bride price and dowry. However, the effects on the number of marriages that transpire (which is reflected in the marriage hazard) is ambiguous; it ultimately depends on which side of the market is more responsive to the shock.

I show that the bride's side of the market is likely to have a greater response to a negative income shock in both regions, due primarily to the large age gap at first marriage.[4] This age gap means that parents of marriageable girls are, on average, younger than parents of marriageable men, and at a lower point of the lifecycle income trajectory. Because they are poorer, parents of brides have a greater need to buffer a negative income shock, which causes them to have a greater response on the marriage market. In Africa, this means that a negative shock leads to an increase in the equilibrium number of marriages, as parents of marriageable girls seek to marry off their daughters in order to secure a bride price to smooth consumption. In India, the equilibrum number of marriages falls in response to a negative shock, since the parents of poorer marriageable girls are unable to pay the dowry demanded by grooms.

Within the context of formulating policy to prevent early marriage, my results highlight the importance of understanding the interdependenies between prevailing social and cultural norms and household responses to economic hardship: as I show here, differences in prevailing customs can result in dramatically different household responses to negative income shocks. More broadly,

[4] In India, the average age gap is about 5.4 years, while in Africa, the age gap is 8.1 years. Figures are based on DHS surveys for India (2005) and sub-Saharan Africa (2006-2012). Considers women aged 20-24 living in rural areas.

my 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 (see, e.g., 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.[5] Here, I show that adjusting the timing of marriage is another strategy that households use to cope with aggregate variation in income, which is also likely to have harmful long-run welfare implications for young women.

The remainder of the paper proceeds as follows. Section 2 provides background information on marriage markets, marriage payments, and early marriage in India and sub-Saharan Africa. Section 3 provides a simple conceptual framework to motivate the empirical approach. Section 4 provides information on the data used in the analysis, and Section 5 explains the empirical strategy. Section 6 summarize the results and provide robustness checks to the identification strategy. 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-accepted strategy to protect their daughter against events (rape and sexual assault,

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

out-of-wedlock pregnancy, etc.) that could compromise her purity and subsequent marriageability. 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.[6]

Although cultural and social norms are important drivers of the persistence 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 (World 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 brideprice) 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.[7] 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.[8]

Although some boys are also at risk, the practice of early marriage is almost entirely a female phenomenon. This seems to be mainly due to the belief that grooms must be able to provide for their wife and future offspring, which is difficult to do at a very young age. As a result, there is typically a significant age gap between husband and wife, which is exacerbated when girls marry at younger ages.

2.2 Dowry and Brideprice

The prevailing economic view of marriage payments is based on the seminal work of Gary Becker (1991). In his framework, marriage is viewed as a joint venture that provides greater efficiency in production than is possible if both partners remain single. Individuals enter into the marriage market to find the 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 brideprices) may emerge as pecuniary transfers that serve to clear the

[6] See Field and Ambrus (2008).

[7] Traditionally, more than 90% of societies in sub-Saharan Africa made brideprice payments (see Anderson, 2007).

[8] 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 et al (2011).

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 brideprices 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 upfront 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.[9]

There are numerous explanations proffered to explain the existence of dowry in India and bride price in Africa. Tambiah and Goody (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 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.

Today, dowry continues to be paid in virtually all marriages in India (Anderson, 2007). The magnitude of dowry payments is large — often significantly above average annual income — and appears to have grown substantially over the first half of the twentieth century (Sautmann, 2012). Various explanations have been advanced to explain this phenomenon, including population growth and the caste system (Anderson, 2003; Rao, 1993; Sautmann, 2012). Bride price is not ubiquitous in contemporary Africa, but the available evidence suggests that it remains an important custom in many parts of the continent, particularly in rural areas. For example, a household panel survey

[9] Some people view dowry as a form pre-mortem bequest made to daughters rather than as a payment that clears the marriage market (Goody 1973). But, as pointed out by Sautmann (2012), this interpretation is at odds with the fact that brides often have minimal say over her dowry.

conducted in Zimbabwe in the mid-1990s by Kinsey (1998) 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.[10] 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. Finally, 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.

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, sometimes 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 comovement 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.

Certainly, while virilocality is a common trend in both regions, the data that is available 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. Mbaye and Wagner (2013) collect data in Senegal which find that women live an average of 20 kilometers from their natal home. As I describe in greater detail below, the fact that women do not move far from their natal home at marriage is important for my identifcation strategy.

[10] Only two of the 520 women interviewed indicated that no bride wealth was given at the time of marriage. See Dekker and Hoogeveen (2002).

3 Conceptual Framework

In this section, I present a simple conceptual framework to explain why weather shocks would have opposite effects on the marriage hazard in India and Africa.[11] In this (static) framework, there are two types of households: bride households and groom households. Bride households consist of one parent and a marriageable daughter, and groom households consist of one parent and a marriageable son. Households receive a (risky) income stream, which they allocate between consumption and marriage payments. Households have concave utility and have no access to formal financial or insurance markets.

Households make two types of decisions: consumption decisions and marriage decisions. Bride households decide the age at which to marry their daugther, and groom households decide the age of their desired bride. Grooms are assumed to prefer marrying younger brides (in line with the available empirical evidence): in addition to their utility from consumption, they derive some benefit $s(a)$ which is decreasing in the bride's age, a. Bride households face some cost of marrying their daughter off too young, denoted by $c(a)$. In India, bride households must pay a dowry to groom households at marriage, while in Africa, bride households receive a bride price (the framework is silent on the reasons behind the direction of marriage payments). Equilibrium marriage payments are those that clear the marriage market: i.e. total demand for brides at each age is equal to total supply of brides at each age, and no individual prefers any other outcome. Because of groom's preferences for younger brides, dowry will be increasing in age and bride price will be decreasing in age.

A negative income shock causes a contraction in income for all households. This has a clear prediction for marriage payments: in both regions, they fall. In Africa, the income shock causes an outward shift in the supply curve of brides, as households are eager to use the bride price to help smooth consumption in the face of the income shock. The shock also causes a contraction in the demand curve of grooms, since in the face of the shock they have less to spend on bride price. These shifts in supply and demand result in a reduction in the equilibrium bride price schedule. The results are similar in the case of India. Unfortunately, there are very few large-scale datasets of dowry and brideprice that can be used to test this hypothesis, so instead I focus on the impact

[11] A more formal model is forthcoming.

on quantity (number of marriages).

While there are clear predictions for prices, the impact on the equilibrium number of marriages is ambiguous. The outcome depends on whether the bride's side (supply) or the groom's side (demand) is more responsive to the shock. I show that the bride's side is likely to be more responsive to a negative income shock, since, on average, households with marriageable girls are poorer than households with marriageable boys. This is primarily due to the age gap at marriage, which means that parents of marriageable girls are, on average, younger than parents of marriageable men, and at a lower point of the lifecycle income trajectory.[12] Because they are poorer, parents of brides have a greater need to buffer a negative income shock, which causes them to have a greater response on the marriage market. In Africa, this means that a negative shock leads to an increase in the equilibrium number of marriages, as parents of marriageable girls seek to marry off their daughters in order to secure a bride price to smooth consumption. In India, the equilibrum number of marriages falls in response to a negative shock, since the parents of poorer marriageable girls are unable to pay the dowry demanded by grooms.

The conceptual framework provides several hypotheses that can be tested in the data:

- Drought (negative income shocks) should lead to increases in hazard into early marriage in Africa, and decreases in the hazard into early marriage in India. Floods (positive income shocks) should lead to decreases in the early marriage hazard in Africa, and increases in the early marriage hazard in India.

- Effects should be larger among poorer bride households, since they are the most exposed to the negative income shock.

- Effects should be concentrated in rural areas, since rural income is much more dependent on rainfall than income in urban areas.

[12]This empirical work is forthcoming in the next draft.

4 Data

4.1 Marriage data

To examine how weather shocks impact marriage outcomes for young women, I 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.[13] For sub-Saharan Africa, I 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. For India, I use the DHS survey from 1998 and the IHDS survey from 2004-05. The two Indian surveys do not contain GPS coordinates, but they provide information on each woman's district of residence, which I can use to match the data to weather outcomes.[14]

The main variable of interest is a woman's age at first marriage. Across all the surveys, this information is collected during the female interview; women are asked to recall the age, month and year when they were first married.[15] However, the universe of women sampled for these interviews differs across surveys. In the DHS Africa, all women in the household between the ages of 15-49 are interviewed, whereas in the DHS India, all ever-married women aged 15-49 are interviewed. 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 introduced by omitting never-married women in the India sample, I limit my 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. Finally, I drop the small number of women born prior to 1950, so that my analysis looks exclusively at women born from 1950 through the mid-1980s. For most of my analyses, I focus exclusively on women in rural areas. After making the restrictions described here, my final sample consists of about 235,000 rural women in sub-Saharan

[13]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 in the field in 2011-12, but is not yet publicly available.

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

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

Africa and 63,000 rural women in India.

Comparison of early marriage rates and marriage hazards Table I presents an overview of the data I use in my main analysis (i.e. rural women, aged 25 and older at the time of interview, born in 1950 or later). There are four main takeaways from the table. First, mean age of marriage is low in both regions, and signficant proportions of women are marrying before age 18. In the sample as a whole, 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, India has both a lower mean age at first marriage and a higher prevalence of child marriage, and due to faster reductions in early marriage in Africa, this difference is increasing over time. Third, in both regions, women that never attended formal schooling are significantly more likely to marry early than women with some formal education. 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 larger for women marrying before age 18.

Figure I plots the hazard and survival functions for my main sample. The survival curves for the two regions are fairly similar to one another at younger ages, when very few women enter into marriage. This is consistent with the fact that girls are often considered to be ready to marry at the onset of puberty, which usually occurs some time in the early teenage years (see Field and Ambrus, 2008). Starting at age 16, however, the curves start to deviate from one another and stay quite different through age 30. The same pattern emerges for the hazard rates, which are fairly close to one another up to age 15, and then diverge from age 16 onwards.

4.2 Weather data and construction of weather shocks

To measure local rainfall shocks, I rely on rainfall data produced by geographers at the University of Delaware. The dataset provides estimates of monthly precipitation on a 0.5 $\times$ 0.5 degree grid covering terrestrial areas across the globe, for the period 1900-2010.[16] Rainfall estimates are based on climatologically-aided interpolation of available weather station information. For sub-Saharan Africa, I use the GPS information to match each DHS cluster to the weather grid cell where it is located. For India, I use GIS software to intersect the weather grid with a district map for India,

[16]0.5 degrees is equivalent to about 50 kilometers at the equator. The University of Delaware (UDel) data has been used in a number of other economic papers, including Dell, Jones, and Olken (2012); Burke, Gong, and Jones (forthcoming). For more information on global weather data sets, see Dell, Jones, and Olken (2013).

and then calculate land-area weighted average rainfall estimates for each district.

I use the UDel data to construct a relative measure of drought (flood), defined respectively as periods of anomalously low (high) rainfall relative to the long-term mean in a particular location. I construct measures and drought and flood for each calendar year, and then match women to a drought observation depending on the month of the observation.[17]

To create a measure of drought, I start by using a long-run time series (1960-2010) of rainfall observations to fit a gamma distribution of rainfall for each grid cell (or district). I then use the estimated gamma distribution for a particular grid cell (district) to assign each rainfall realization in that location to its corresponding percentile in the distribution.[18] I define a drought as a rainfall realization that is in the bottom 15th percentile of that location's rainfall distribution. The process for creating a measure of flood is the same, but the cutoff is a rainfall realization that is in the top 15th percentile of the distribution (i.e. 85th percentile and above). The decision to use these particular cutoff values is informed by previous economic literature. They are also comparable to the definition of "moderate drought" and "moderate flood" used by some meteorologists.[19] I present results that modify these cutoffs in the robustness section.

The most important consequence of constructing weather shocks in this manner is that every area has the same likelihood of experiencing drought (flood) each year, regardless of the underlying climatological conditions. In other words, the measure of drought (flood) should orthogonal to local climatology, as well as to other features of the area that are unobserved in the data but might impact the incidence of child marriage.

5 Empirical Strategy

To examine the impact of weather shocks on the incidence of early marriage, I estimate a linear approximation of a discrete-time hazard (duration) model.[20] The duration of interest is the time

[17] Women married or interviewed in the second half of year t are matched to weather shocks in year t, while women married or interviewed in the first half of year t are matched to weather shocks in year $t-1$. I have also looked at weather shocks during the rainy seasons in each region, and results are similar but more muted.

[18] This approach is also used by Burke, Gong, and Kelly (2014).

[19] One way that meteorologists measure drought is through a standardized precipitation index (SPI), which is constructed in a very similar manner to what I have done here. My 15th percentile cutoff is roughly equivalent to a standardized precipitation index (SPI) value of -1.0, which indicates moderate drought conditions.

[20] 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.

between t_o, the age when a woman is first at risk of getting married, and the age when she enters her first marriage. In my analysis, t_o is assumed to be age 10, which is the minimum age for which a non-negligible number of women in my sample report getting married for the first time.

In order to estimate the model, I first convert my data into person-year format. A woman who is married at age n is treated as if she contributed $n - t_o$ observations to the sample, one observation for each at-risk year until she is married and exits the sample. 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 I am interested in early marriage, in most regressions I only follow women up until age 17. Women married after age 17 are right censored.[21]

I use the person-year data to estimate the probability of woman i living in area k entering her first marriage at age t:

$$M_{i,k,t} = \alpha(t) + Z_i'\gamma + X_{k,t-1}'\beta + \omega_j + \epsilon_{i,k,t} \tag{1}$$

In this equation, $\alpha(t)$ reflects the baseline hazard into marriage, Z_i are time-invariant female characteristics, and $X_{k,t-1}$ are time-varying measures of weather conditions in area k in the prior year. In the Africa sample, area (the k) refers to grid cells, whereas in the India sample, area refers to administrative districts. I also include region fixed effects, ω_j, to control for time-invariant unobservables in the region. In the Africa sample, these fixed effects are at the regional level within each country, while in the India sample, regions are Indian administrative districts.[22] I specify the baseline hazard in the most flexible way possible, with indicators for each age (i.e. $\alpha(t) = \alpha_{10}D_{10} + \alpha_{11}D_{11} + \ldots + \alpha_{17}D_{17}$). 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 I include in Z_i are birth cohort fixed effects (1950s, 1960s, etc.) as well as an indicator for whether a woman ever attended formal school. Included in $X_{k,t-1}$ are a dummy indicator for a negative rainfall shock (drought) in the prior year, and a dummy indicator for a positive rainfall shock (flood) in the prior year. Since I am combining

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

[22] In other words, for India $j = k$, whereas in Africa, a region j is comprised of many grid cells k.

data across multiple survey instruments, I use population-weighted survey weights to make results representative of the countries included in the analysis. I estimate regressions with standard errors clustered at the grid-cell (for Africa) or district (for India) level, to allow for corrleation in error terms across individuals in the same area.

5.1 Identification

With the inclusion of regional fixed effects, the impact of weather shocks is identified from within-region variation in weather shocks and marriage outcomes. The key identifying assumption of the analysis is that, within regions, the weather shocks included in X_{kt} are orthogonal to potential cofounders. 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 my setting because, given the retrospective nature of my analysis, there are many unobservables for which I cannot control.[23] In the robustness section I provide evidence that results are not being driven by unobservables, and that the results are not sensitive to alternative constructions of the rainfall shocks in X_{kt}.

Another 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 my estimates. Marriage is an important event in women's lives, so it seems unlikely that they would be unable to remember when they were married, but recall bias is likely to be increasing in the time since first marriage.

Finally, a major threat to identifcation comes from the fact that I only have information on where women currently reside, and not on where they resided around the time of the marriage decision. This introduces two potential problems to the analysis. First, given the custom of virilocality, many women move away from their natal village at the time of marriage, so where they live today will be different than the place where they grew up. Second, even after marriage, the household may have migrated to another location. I argue that neither of these problems is a major threat to my analysis, for two reasons. First, the available data on virilocality (summarized

[23] Most importantly, I 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).

in Section 2) suggest that most women do not move far from their place of birth. So, even if women move, they have most likely not moved out of the geographic area within which I define my rainfall shocks (administrative districts in India, grid cells in Africa). Post-marriage migration is also most likely not an issue, since I am focused on women currently residing in rural areas, and rural-rural migration prevalence is low. Luckily, the DHS and IHDS surveys collect some limited information on migration patterns of women; in particular, they ask how long women have lived in a particular community. I can use this information to re-run my analysis conditioning on women who have resided in the same location since before they were married, which I do in the robustness section.

6 Results

6.1 Main results

Table II displays results of Equation (1) estimated separately on the data for Sub-Saharan Africa (Panel A) and India (Panel B). The first two columns present results for all women (rural and urban), and the third column presents results for rural women only. In line with the predictions of the framework presented in Section 3, weather shocks have opposite effects on the early marriage hazard in the two regions. In Sub-Saharan Africa, drought *increases* the hazard into early marriage by 0.5 percentage points in the sample as a whole, and 0.6 percentage points in rural areas. By contrast, in India, drought *reduces* the likelihood of early marriage by 0.5 percentage points in the sample as a whole, and 0.8 percentage points in rural areas. Flood reduces the marriage hazard in the Africa sample (by about 0.3 percentage points in rural areas), but has no measurable impact on the early marriage hazard in India. The specification presented in column (2) interacts the weather shock variables with an indicator for urban residence. In Africa and India, weather shocks appear to have no effect on the early marriage hazard in urban areas, which is consistent with the notion that household income for urban households is less affected by weather shocks.

The results presented in Table II estimate the average effect of weather shocks across all ages represented in the data (age 10 to age 17). However, effects are likely to vary by age. To look at how effects of weather shocks vary by age, I estimate a version of Equation (1) that interacts weather shocks with indicators for two age categories: Age 10-14, and Age 15-17. I also estimate a version that censors women after age 25 (rather than after age 17) and includes an additional interaction term between the weather shocks and an indicator for ages 18 and older. The results of these regressions, presented in Table III, show that weather shocks have the greatest effects on the marriage hazard for women in their mid-teens (Age 15-17). In fact, the interaction terms for the youngest age category are never significantly different from zero. This may be because large fraction of girls in this age range have not begun menstruation, which has been found to be an important biological milestone after which marriage hazards increase (see Field and Ambrus, 2005).

Figures II and III provide a graphical representation of the results using the data up until age 25. In the Africa sample, drought at age 15-17 increases the marriage hazard by 4.2 percentage points, which translates into a 25.4% increase in the marriage hazard, on average, for this age group. Floods reduce the marriage hazard by 5.5%, on average, for girls in this age group. There is no significant effect of flood or drought for younger girls. Looking at women who marry after age 17, I estimate negative effects of drought and flood on the marriage hazard (9.0% and 5.1% reduction in the marriage hazard due to drought and flood, on average). In India, drought at age 15-17 leads to a 2 percentage point reduction in the marriage hazard, which translates into an average reduction of 9.7% for this age group. The estimated effects on the hazard for girls in their early teens and those older than 17 are not signficantly different from zero. Results are also insignificant for floods across all age categories.

The conceptual framework presented earlier predicts that the poorest households will have the greatest responses to aggregate income shocks. We lack information on the income or wealth level of a woman's household during the period of analysis, but we can use the information on women's schooling to see at least whether weather shocks have larger effects among women with no formal schooling. Given the socio-economic gradient in educational attainment for women, this should be a reasonable proxy for the poorest women. Columns (1) and (3) of Table IV present these results. As predicted, effects are stronger among women with no formal schooling in both India and Africa.

Finally, we can look for evidence of heterogeneous effects by birth cohort. According to Columns (2) and (4) of Table IV, effects of weather shocks on the hazard into early marriage are more muted in younger birth cohorts. 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 may also be playing a role.

6.2 Robustness

Omitted variables

The first robustness check I perform[24] is a placebo test to verify that my results are not being driven by omitted variables that are (a) correlated with my weather shocks and (b) also factors that affect the marriage hazard. In order to do this, I 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 my results are being driven by correlation betwen weather shocks and time invariant local area charactertistics, then these placebo regressions will yield statistically significant results. However, if I am capturing a true relationship between drought and marriage rates, then future shocks should have no impact on the marriage hazard. In Table V, I present the results of these placebo tests, using measures of drought and flood 1 to 5 years in the future. In nearly all cases in these placebo regressions, results are not significantly different from zero. The drought coefficients on the first two leads are significant for Africa, but the fact that this disappears suggests that the significance of these coefficients is coming from measurement error in women's responses rather than true omitted variables bias.

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. I provide a conceptual framework arguing that these opposing effects are driven by differences in the direction of marriage payments in each region. 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, something that until now has mostly been presumed based on the associational evidence. Second, they underscore the important interdepencies 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.

[24] Additional robustness checks are forthcoming

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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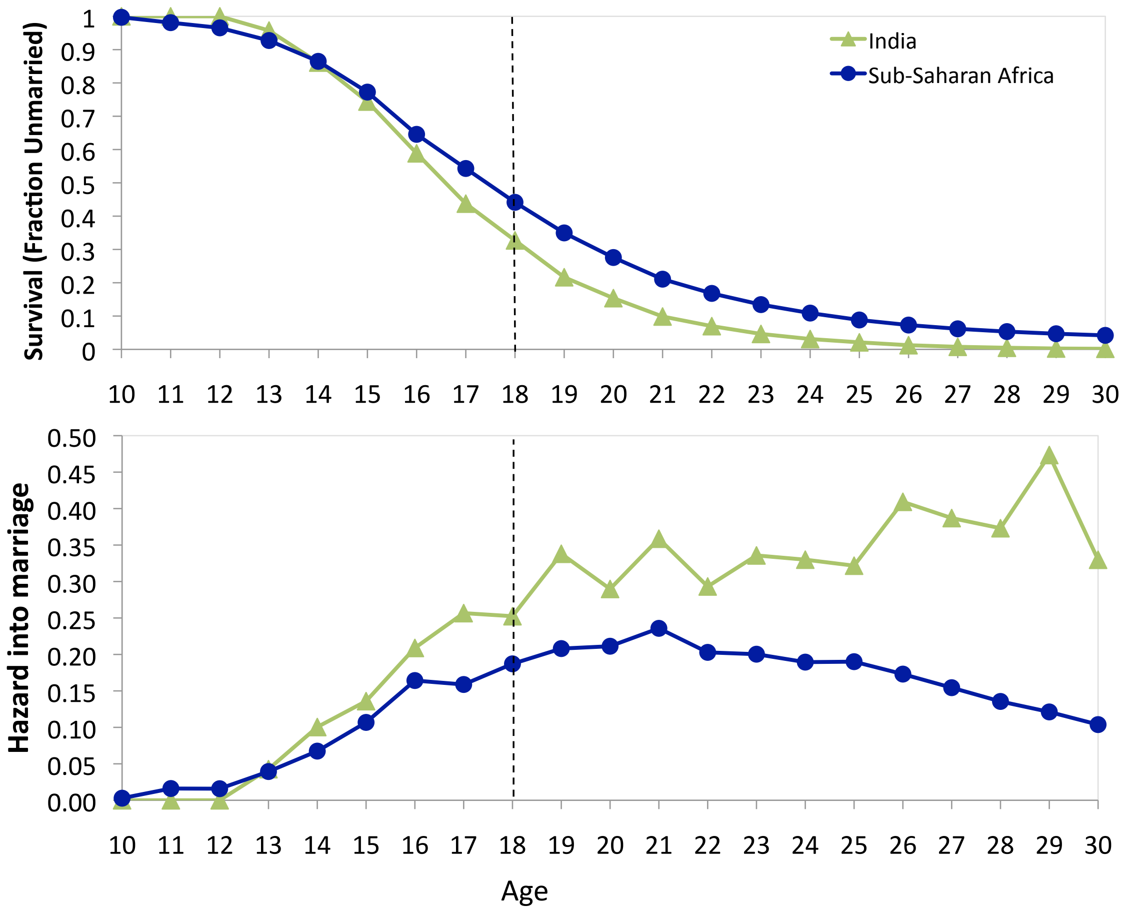
Table I: Summary statistics on main sample used in analysis

	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.

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.

Table II: Effect of rainfall shocks on hazard into early marriage

	(1) Rural & Urban	(2) Rural & Urban	(3) Rural only
Panel A: Sub-Saharan Africa			
Drought	0.005**	0.007**	0.006**
	(0.002)	(0.003)	(0.003)
Flood	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)
Drought*Urban		-0.006	
		(0.005)	
Flood*Urban		0.002	
		(0.002)	
Drought + Drought*Urban		0.001	
		(0.003)	
Flood + Flood*Urban		-0.001	
		(0.002)	
Person-year observations	2,384,125	2,384,125	1,631,298
Women	337,957	337,957	234,840
R^2	0.078	0.078	0.084
Panel B: India			
Drought	-0.005***	-0.008***	-0.008***
	(0.002)	(0.003)	(0.003)
Flood	0.000	0.002	0.001
	(0.002)	(0.003)	(0.003)
Drought*Urban		0.007**	
		(0.003)	
Flood*Urban		-0.004	
		(0.004)	
Drought + Drought*Urban		-0.001	
		(0.002)	
Flood + Flood*Urban		-0.003	
		(0.002)	
Person-year observations	535,400	535,400	333,642
Women	96,869	96,869	62,859
R^2	0.105	0.105	0.113

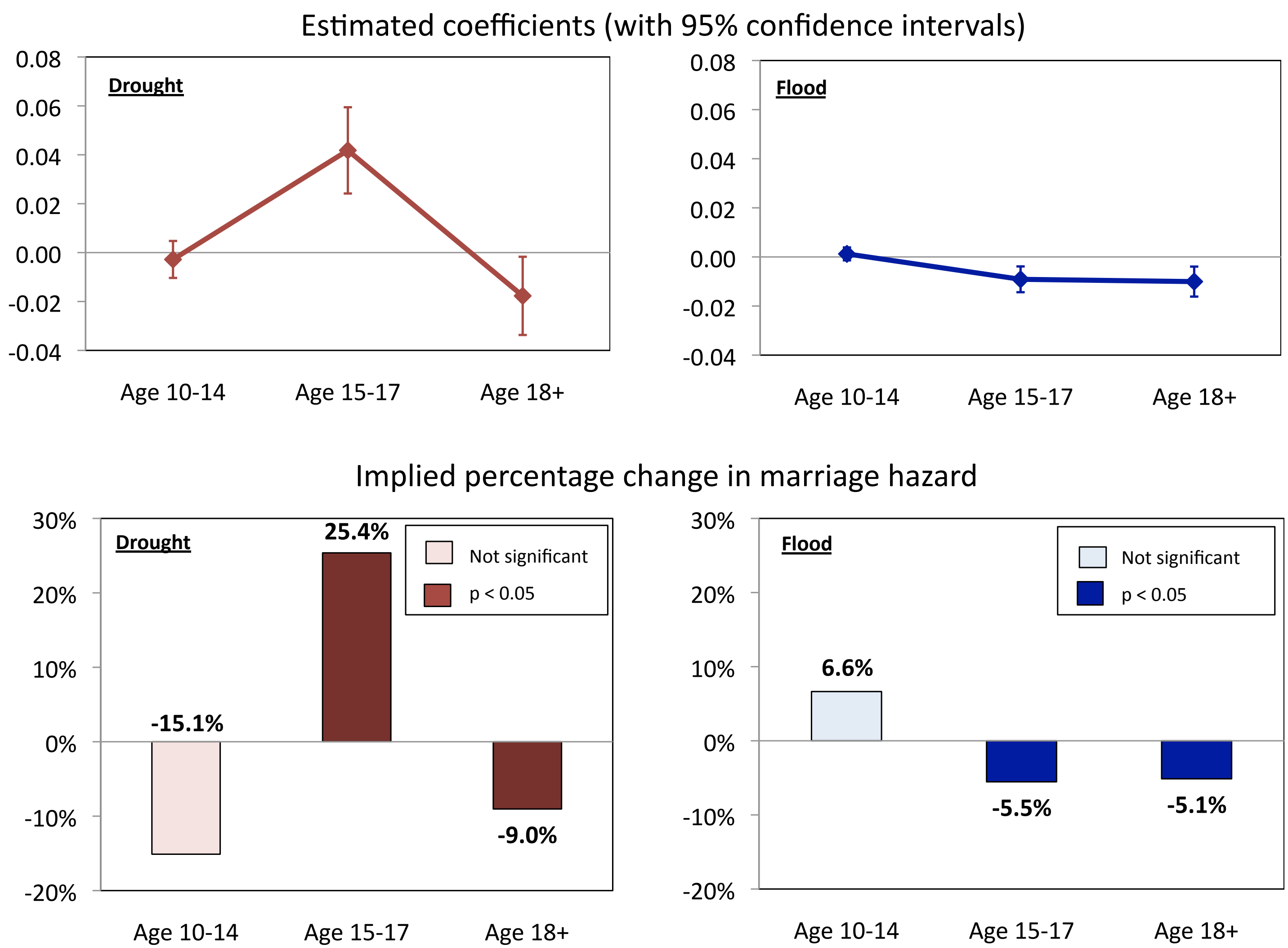
Estimated using OLS; sample includes person-year observations up to age 17 for each woman. Specifications include indicator variables for: age, decade of birth, urban/rural designation (where applicable), and whether a woman ever attended school. Specifications also include regional fixed effects (at the country-region 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 III: Effect of weather shocks at different ages (rural areas only)

	Africa		India	
	Age < 18 (1)	Age < 26 (2)	Age < 18 (3)	Age < 26 (4)
Drought - Age ≤ 14	-0.005	-0.003	-0.002	-0.002
	(0.004)	(0.004)	(0.003)	(0.003)
Drought - Age 15-17	0.041***	0.042***	-0.020***	-0.020***
	(0.009)	(0.009)	(0.006)	(0.006)
Drought - Age 18+		-0.018**		0.007
		(0.008)		(0.009)
Flood - Age ≤ 14	0.000	0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.003)	(0.003)
Flood - Age 15-17	-0.011***	-0.009***	0.007	0.008
	(0.003)	(0.003)	(0.008)	(0.008)
Flood - Age 18+		-0.010***		0.014*
		(0.003)		(0.008)
Person-year observations	1,631,298	2,084,148	333,642	418,459
Women	234,840	234,840	62,859	62,859
R^2	0.084	0.082	0.113	0.125

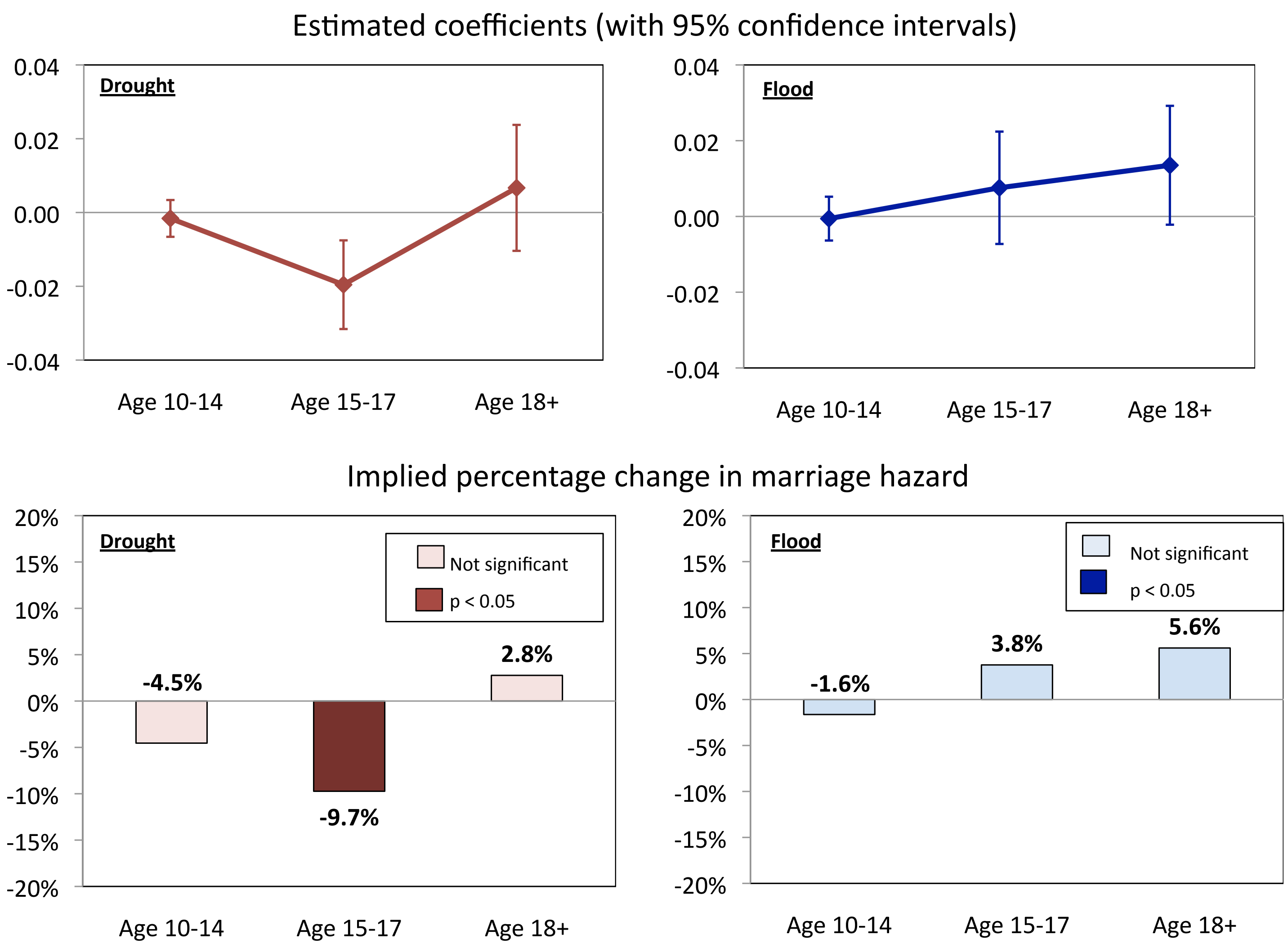
Estimated using OLS; sample includes person-year observations up to age 17 for each woman in columns (1) and (3); and person-year observations up to age 25 for each woman in columns (2) and (4). Rural areas only. Specifications include indicator variables for: age, decade of birth, and whether a woman ever attended school. Specifications also include regional fixed effects (at the country-region 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.

Figure II: Effect of weather shocks at different ages, Sub-Saharan Africa (rural areas only)



Notes: The top panel panel plots the estimated coefficients from column (2) of Table III, with 95% confidence intervals. The bottom panel shows the implied change in the marriage hazard (average over all ages in each category).

Figure III: Effect of weather shocks at different ages, India (rural areas only)



Notes: The top panel panel plots the estimated coefficients from column (4) of Table III, with 95% confidence intervals. The bottom panel shows the implied change in the marriage hazard (average over all ages in each category).

Table IV: Heterogeneous effects of rainfall shocks (rural areas only)

	Africa		India	
	(1)	(2)	(3)	(4)
Drought	0.001	0.010*	-0.006*	-0.011***
	(0.005)	(0.005)	(0.003)	(0.004)
Flood	-0.001	-0.004**	0.006	0.002
	(0.001)	(0.002)	(0.006)	(0.005)
Drought*No School	0.008		-0.003	
	(0.007)		(0.005)	
Flood*No School	-0.003		-0.008	
	(0.002)		(0.007)	
Drought*Born in 70s or 80s		-0.005		0.008
		(0.007)		(0.005)
Flood*Born in 70s or 80s		0.001		-0.002
		(0.002)		(0.006)
Drought + Drought*No School	0.008**		-0.009**	
	(0.004)		(0.004)	
Flood + Flood*No School	-0.004***		-0.002	
	(0.001)		(0.004)	
Drought + Drought*Born in 70s or 80s		0.005		-0.003
		(0.004)		(0.004)
Flood + Flood*Born in 70s or 80s		-0.002*		0.000
		(0.001)		(0.004)
Person-year observations	1,631,298	1,631,298	333,642	333,642
Women	234,840	234,840	62,859	62,859
R^2	0.084	0.084	0.113	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 regional fixed effects (at the country-region 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: 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	0.006**	0.008**	-0.002	-0.004	0.000
	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)
Flood	-0.004***	-0.003**	-0.002	-0.002	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Person-year observations	1,631,297	1,631,297	1,631,297	1,631,297	1,631,297
Women	234,840	234,840	234,840	234,840	234,840
R^2	0.084	0.084	0.084	0.084	0.084
Panel B: India					
Drought	0.004	0.004*	-0.001	-0.001	0.004
	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
Flood	-0.001	-0.002	-0.003	-0.001	0.000
	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
Person-year observations	219,208	219,208	219,208	219,208	219,208
Women	46,504	46,504	46,504	46,504	46,504
R^2	0.101	0.101	0.101	0.101	0.101

Estimated using OLS. Specifications include dummy variables for age, decadal birth cohorts, an indicator for whether a woman ever attended school, and area fixed effects (fixed effects are at the country-region 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.