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

Lucia Corno† Nicole Hildebrandt‡ Alessandra Voena §

December 30, 2016

Abstract

Cultural norms play an important role in influencing economic behavior and can shape households' decisions even in response to the same economic circumstances. For this reason, they may influence economists' ability to extrapolate the empirical findings from natural experiments. This paper examines the effect of local rainfall shocks on female child marriages in sub-Saharan Africa and in India. We show that droughts have similar negative effects on crop yields, but opposite effects on child marriage in the two regions: in Africa, droughts increase the probability of child marriage, while in India droughts decrease such a probability. To explain this outcome, we develop a simple equilibrium model of the marriage market in which income shocks affect the timing of marriage because the transfers that occur at the time of marriage are a source of consumption smoothing, particularly for a woman's family. Exploiting heterogeneity in the marriage payment traditions across countries and ethnic groups, and additional data from Indonesia, we argue that the differential impact of drought on the marriage hazard is explained by differences in the direction of traditional marriage payments in each region, bride price across sub-Saharan Africa and Indonesia and dowry in India.

JEL Codes: J1, O15.

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

*We thank David Atkin, Marianne Bertrand, Bill Easterley, Raquel Fernàndez, Paola Giuliano, Luigi Guiso, Seema Jayachandran, Nathan Nunn, Yaw Nyarko, Debraj Ray, Dean Spears, and participants in presentations at SITE, EUDN, Harvard/MIT, and CEPR for helpful comments. Yin Wei Soon provided outstanding research assistance.

†Catholic University of the Sacred Heart and IFS. Email: lucia.corno@unicatt.it.

‡Boston Consulting Group Email: nhilde1@gmail.com.

§The University of Chicago, NBER and CEPR. Email: avoena@uchicago.edu.

Social scientists have now well recognized the important role of cultural and traditional norms in shaping economic behavior both in developed and in developing countries. Recent studies have also shown that social norms can contribute to the effectiveness of development policies, and there have been increasing calls by international organizations, such as the World Bank and the United Nations, for improving the tailoring of interventions to the local context.[1] In this paper, we argue that cultural norms may also influence economists' ability to extrapolate the empirical findings from natural experiments, by radically modifying the economic relationship between variables, and hence may play a significant role in policy design and evaluations.

We examine female child marriage, a widespread and dramatic phenomenon in the developing world. Because of the strong association between child marriage and poverty worldwide, it is natural to ask whether negative economic shocks are a direct cause of child marriages. To study this question, we examine the effect of rainfall shocks –a major source of income variability in rural areas that rely on rain-fed agriculture– on the probability of early marriage among young women in two regions of the world, sub-Saharan Africa and India. In these areas, low realizations of local rainfall have similar negative effects on agricultural output, but opposite effects on early marriage: in sub-Saharan Africa, droughts increase the hazard of marriage before age 18, while in India, droughts reduce such a hazard.

In particular, to measure the effect of income shocks on early marriage, we combine rainfall data from the University of Delaware Air Temperature and Precipitation project (UDel) between 1950 and 2010 with marriage data from sixty pooled Demographic and Health Surveys (DHS) for thirty sub-Saharan African countries between 1994 and 2012, from the 1998-1999 DHS of India, and the 2005 Indian Human Development Survey (IHDS). We obtain information on the age of marriage and on the history of rainfall shocks of approximately 450,000 women for every year between age ten and age seventeen. To investigate the effect of rainfall shocks on agricultural output, we also merge the UDel data with historical data on crops yields provided by Food and Agricultural Organization (FAO) and by the World Bank.

Our main result shows that a drought, defined as an annual rainfall realization below the fifteenth percentile of the local rainfall distribution, increases the annual hazard of marriage between ages ten and seventeen by 3.5 percent in sub-Saharan Africa. A flood, defined as an

[1] The most recent World Development Report focuses on the idea that "paying attention to how humans think (the processes of mind) and how history and context shape thinking (the influence of the society) can improve the design and the implementation of development policies that target human choice and action (behavior)" (World Bank, 2015).

annual rainfall realization above the eighty-fifth percentile of the local rainfall distribution, is associated with a 3.5 percent lower hazard into early marriage. In India, a drought decreases the hazard of marriage between ages ten and seventeen by 5 percent, while we find no relationship between floods and the timing of marriage.

We hypothesize that the differential impacts of droughts across these two regions can be explained by differences in the direction of the traditional marriage payments. In many countries in sub-Saharan Africa, it is customary for the groom or his family to pay a bride price to the bride's family, whereas in India, the prevailing tradition is for the bride's family to pay a dowry to the groom or his family at the time of marriage. We develop a simple equilibrium model of child marriage in which the direction of marriage payments arises from historical gender roles due to available agricultural technology, as hypothesized by Boserup (1970). In the model, families hit by poor income realizations adjust the timing of marriage of their children in order to use the resources provided by these marriage payments. When a son's contribution to the household budget constraint is large enough, we expect equilibrium child marriages to increase in sub-Saharan Africa, where marriage requires a payment from the groom to the bride's family, and to decrease in India, where marriage requires a payment from the bride's family to the groom or his family.

We provide empirical evidence in support of this interpretation. Within sub-Saharan Africa, where there is substantial variation in local marriage payment norms, we show that the positive effect of droughts on the hazard into early marriage is concentrated in countries that have higher prevalence of ethnic groups that traditionally make bride price payments at marriage. Even within Zambia, that has substantial variation in traditional marriage payments norms, we show that ethnic groups that traditionally engage in marriage payments are the most sensitive to droughts and floods. Within India, where there is limited variation in cultural norms, we instead examine the heterogeneity in the historical banking development, and show that our effects are stronger when and where bank development is lower, suggesting that it is indeed the consumption-smoothing role of marriage payments that influences the timing of marriage. Finally, we bring additional evidence from Indonesia, a country with a large number of ethnic groups traditionally practicing bride price, where we find effects comparable to the ones documented in Sub-Saharan Africa.

Our paper is related to three strands of literature in economics. First, it fits in the broad body of research on the importance of culture in shaping economic behavior. Much of this work has looked at the role of cultural values and beliefs, such as trust, family ties, and preferences about women's role, on economic development (Fernandez, Fogli, and Olivetti, 2004; Fernandez and Fogli, 2009; Algan and Cahuc, 2010; Alesina, Algan, Cahuc, and Giuliano, 2010; Tabellini, 2010; Nunn and Wantchekon, 2011). A growing part of this literature has explored the influence of traditional social norms - behaviors that are enforced through social sanctions - on economic behavior. For example, La Ferrara (2007) and La Ferrara and Milazzo (2012) test the implication of the matrilineal inheritance rule on inter-vivos transfer and on human capital accumulation in Ghana, where the largest ethnic group is traditionally matrilineal. In the domain of traditional marriage practices, Jacoby (1995) studies the effect of polygyny on women agricultural productivity and find that, conditional on wealth, men do have more wives when women are more productive. Tertilt (2005) shows that banning polygyny lowers fertility and shrinks the spousal age gap in sub-Saharan Africa. While marriage payments –dowry and bride price– are widespread in many regions in Africa and Asia only few studies have looked at their effect on household's economic decision. In a recent paper, Ashraf, Bau, Nunn, and Voena (2016) show that ethnic groups that traditionally engage in bride price payment at marriage in Indonesia and Zambia are more likely to see female enrollment increase in response to a large expansion in the supply of schools. In those communities, higher female education at marriage is associated with a higher bride price payment received thus providing a greater incentive for parents to invest in girls' education.

Second, 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 insurance arrangements (see Townsend (1994), Dercon (2002), De Weerdt and Dercon (2006), Fafchamps and Gubert (2007) and Angelucci, De Giorgi, Rangel, and Rasul (2010) among others). 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 (Morten, 2016), off-farm employment, and liquidation of buffer stock (Fafchamps, Udry, and Czukas, 1998), are typically unable to provide full consumption smoothing. This challenge 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.[2] In this paper, 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.

Finally, the paper contributes to understanding the reasons for child marriage. Despite improvements in female educational and economic opportunities, large numbers of young women continue to marry at an early age. Worldwide, more than 700 million women alive today were married before their 18th birthday and 25 million entered into union before age 15 (UNICEF, 2014). Child marriage (defined as marriage before the age of 18) is especially pronounced among women living in sub-Saharan Africa and South Asia, where more than 50% of women continue to marry before age 18, and 20% marry before age 15.[3]

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.[4] Within the context of formulating policy to prevent early marriage, our results highlight the importance of understanding the relationship between prevailing cultural norms and household economic behavior.

The remainder of the paper proceeds as follows. Section 1 provides background information on marriage markets, marriage payments, and early marriage in India and Africa. Section 2 illustrates the equilibrium model. 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] 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).

[3] Figures are based on DHS surveys for India (2005) and Africa (2006-2012), considering women aged 20-24 living in rural areas. See table A2 for the African countries included in the analysis.

[4] 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.

1 Background

Early marriage and marriage payments are both widespread practices in developing countries, particularly in sub-Saharan Africa and in South Asia.

1.1 Early marriage

Early marriage continues to persist in many countries around the world, but it is most prevalent in rural areas of South Asia and sub-Saharan Africa. 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 more fertile, more likely to be sexually inexperienced and easier to control (Field and Ambrus, 2008).

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 (Bank, 2014). 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 at first increasing and then rapidly decreasing in bride's age, meaning that under both customs, marrying a daughter earlier can be financially more attractive for her parents.[5]

1.2 Marriage payments

The prevailing economic view of marriage payments is based on the seminal work of Becker (1991). In Becker's theory, 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

[5] For evidence on the relationship between dowry and bride's age in India, see Chowdhury (2010). Empirical data on bride price is very limited, but for evidence on bride price and bride's age in the Kagera Health and Development Survey from Tanzania, see Corno and Voena (2016).

market to find the match that maximizes their expected utility; the marriage market matches partners and determines the division of surplus between them. Given this characterization, marriage payments (dowries and bride prices) may emerge as pecuniary transfers that serve to clear the marriage market. Different types of 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 scarce, grooms pay bride prices to brides. Alternatively, payments can arise as the transfers to equilibrate the market when 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 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.[6]

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, dowry is the most common practice. 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). 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 (2016) document that the practice

[6] 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 studied 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)).

is widespread in modern-day Lusaka (Zambia), with payments often exceeding annual per capita GDP.

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 (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).[7]

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 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, which has been shown to explain model gender roles (Alesina, Giuliano, and Nunn, 2013), finds empirical support in Giuliano (2014) that documents a positive correlation between women's role in agriculture and marriage payments.

2 Theoretical framework

Below, we develop a simple equilibrium model that proposes a channel through which marriage payments affect the way in which aggregate income shocks affect the probability of child

[7] Other work has examined the role of dowry in Europe, see Botticini (1999); Botticini and Siow (2003).

marriages. To the best of our knowledge, this is the first model to allow for equilibrium determination of both bride price and dowry payments, and for their dynamics by age of the bride.

In this section, we present a version of the model with log-utility and uniform distribution of the heterogeneity. In Appendix C, we extend this framework to any concave and differentiable utility function and any continuous distribution of the heterogeneity, showing that our proposition are valid in this more general setting.

2.1 Setup

There is a measure one of households with a daughter and a measure one of households with a son. There are two periods, which correspond to two stages of a woman's life, childhood ($t = 1$) and adulthood ($t = 2$).

In each period, household income depends on adult children's contributions, on an aggregate realization of weather, which can take values $y_t \in \{y^L, y^H\}$, with $y^L < y^H$, each occurring with equal probability independently in every period, plus an idiosyncratic realization ϵ_t which is distributed uniformly on $[0, 1]$. Hence, in period t, the total income of a household i with an adult daughter is equal to $y_t + \epsilon_t^i + w^f$, where w^f is a woman's contribution to the household budget. Following Boserup's interpretation of the historical origins of marriage payments, we consider *historical* w^f to be either positive or negative depending on the available technology in the local community, as a determinant the direction of the marriage payment. The total income of a household j with an adult son is equal to $y_t + \epsilon_t^j + w^m$.

The society is patrilocal, and hence upon marriage women move to the groom's family and contribute to its budget. In addition, with marriage, the groom's family acquires offspring, which deliver utility $\xi^m > 0$ in each period. There is also a potential utility gain of a woman's family stemming from marrying off a daughter, denoted as $\xi^f \geq 0$.

2.1.1 Adulthood

In adulthood, marriage will occur if there exists a transfer for which both parties prefer marriage to remaining single. This implies that there exists a τ_2^* that satisfies

$$ln(y_2 + \epsilon_2^i + \tau_2^*) + \xi^f \geq ln(y_2 + \epsilon_2^i + w^f)$$

$$ln(y_2 + \epsilon_2^j + w^m + w^f - \tau_2^*) + \xi^m \geq ln(y_2 + \epsilon_2^j + w^m).$$

One simple hypothesis for the emergence of marriage payments is that, when aggregate income is sufficiently low, the bounds on τ_2^* require a payment to take place even for the richest families. In sub-Saharan Africa, with historical $w^f > 0$, a bride price payment may have been necessary to persuade women's parents to let their daughters marry, meaning that

$$ln(y_H + 1 + w^f) > ln(y_H + 1) + \xi^f.$$

In India, where historically $w_f < 0$, a dowry payment may have been necessary to persuade men to support a bride into their household:

$$ln(y_H + 1 + w^m) > ln(y_H + 1 + w^m + w^f) + \xi^m.$$

These conditions imply that a lower bound on the marriage payment is equal to $\underline{\tau}_2 = \frac{1-exp(\xi^f)}{exp(\xi^f)}(y_2 + \epsilon_2^i) + \frac{w^f}{exp(\xi^f)}$, while the upper bound is $\bar{\tau}_2 = \frac{exp(\xi^m)-1}{exp(\xi^m)}(y_2 + \epsilon_2^j + w^m) + w^f$.

One simple example of equilibrium is that men make a take-it-or-leave-it offer to the woman's parents, and the parents decide whether or not to accept. For example, when $\xi^f = 0$, men offer $\tau_2^* = w^f$. Hence, whenever $w^f < 0$, the transfer is a dowry, i.e. a payment from the bride's family to the groom's family, while with $w^f \geq 0$, the payment is a bride price, i.e., a payment from the groom's family to the bride's family.

In what follows, we assume that there exists a payment $\tau_2^* \in [\underline{\tau}_2, \bar{\tau}_2]$. The direction of that payment is due to the historical sign of w^f, but we do not impose that present-day w_f has to differ across areas of the world. Given that payment τ_2^*, payoffs from marrying in the second period are:

$$u_{2j}^{m0} = ln(y_2 + \epsilon_2^j + w^m + w^f - \tau_2^*) + \xi^m \qquad \text{and} \qquad u_{2i}^{f0} = ln(y_2 + \epsilon_2^j + \tau_2^*) + \xi^f.$$

If a couple is already married when entering the second period, the families' payoffs instead are

$$u^{m1}_{2j} = ln(y_2 + \epsilon^j_2 + w^m + w^f) + \xi^m \qquad \text{and} \qquad u^{f1}_{2i} = ln(y_2 + \epsilon^i_2).$$

2.1.2 Childhood

In the first period, parents decide whether or not to have their children marry. For a given transfer τ_1 paid in marriages that occur in the first period, payoffs are the following. If marriage occurs:

$$u^m_{1j} = ln(y_1 + \epsilon^j_1 - \tau_1) + \xi^m + E\left[ln(y_2 + \epsilon^j_2 + w^m + w^f) + \xi^m\right]$$

$$u^f_{1i} = ln(y_1 + \epsilon^i_1 + \tau_1) + \xi^f + E\left[ln(y_2 + \epsilon^i_2) + \xi^f\right].$$

Instead, if marriage is delayed:

$$u^m_{1j} = ln(y_1 + \epsilon^j_1) + E\left[ln(y_2 + \epsilon^j_2 + w^f - \tau^*_2 + w^m) + \xi^m\right]$$

$$u^f_{1i} = ln(y_1 + \epsilon^i_1) + E\left[ln(y_2 + \epsilon^i_2 + \tau^*_2) + \xi^f\right].$$

A woman from household i will get married in the first period if and only if:

$$ln(y_1 + \epsilon^i_1 + \tau_1) + \xi^f - ln(y_1 + \epsilon^i_1) \geq E\left[ln(y_2 + \epsilon^i_2 + \tau^*_2)\right] - E\left[ln(y_2 + \epsilon^i_2)\right]$$

A man from household j will get married in the first period if and only if:

$$\begin{aligned} ln(y_1 + \epsilon^j_1 - \tau_1) + \xi^m - ln(y_1 + \epsilon^j_1) \geq \\ E\left[ln(y_2 + \epsilon^j_2 + w^m + w^f - \tau^*_2)\right] - E\left[ln(y_2 + \epsilon^j_2 + w^m + w^f)\right]. \end{aligned}$$

Define the right handside terms as $\Omega^f = E\left[ln(y_2 + \epsilon^i_2 + \tau^*_2) - ln(y_2 + \epsilon^i_2)\right]$ and $\Omega^m = E\left[ln(y_2 + \epsilon^j_2 + w^m + w^f - \tau^*_2) - ln(y_2 + \epsilon^j_2 + w^m + w^f)\right]$. For simplicity, define also $H^f = exp(\Omega^f - \xi^f)$ and $H^m = exp(\Omega^m - \xi^m)$.

Demand and supply for brides in sub-Saharan Africa When $\tau^*_2 > 0$, $\Omega^f > 0$. To have some couples not marry in the first period, we have $H^f > 1$. Also $\Omega^m < 0$, and $\xi^m > 0$ implies that $H^m < 1$.

For a given τ_1, define a marginal household with daughter i such that:

$$ln(y_1 + \epsilon_1^{f*} + \tau_1) + \xi^f - ln(y_1 + \epsilon_1^{f*}) = \Omega^f$$

Given the expression above, there exists a threshold income shock for women's parents such that, when $\epsilon_t^i < \epsilon^{f*}(\tau_1)$, parents will want their daughter to marry in the first period. Hence, because of the uniform assumption, a measure ϵ^{f*} of women wants to get married. The supply of brides, defined on the $[0,1]$ interval, takes the form

$$S^{SSA}(y_1, \tau_1) = \frac{\tau_1}{H^f - 1} - y_1.$$

and is decreasing in the aggregate income y_1 and increasing in τ_1.

For a given τ_1, also define a marginal household with son j such that:

$$ln(y_1 + \epsilon^{m*} - \tau_1) + \xi^m - ln(y_1 + \epsilon^{m*}) = \Omega^m.$$

For $\epsilon_t^j > \epsilon^{m*}$, men want to also marry in the first period. Hence, because of the uniform assumption, a measure $1 - \epsilon^{m*}$ wants to get married. The demand for brides, again defined on the $[0,1]$ interval, takes the form

$$D^{SSA}(y_1, \tau_1) = 1 + y_1 + \frac{\tau_1}{H^m - 1},$$

which is increasing in the aggregate income y_1 and decreasing in τ_1.

Demand and supply for brides in India In India, $\tau_2^* < 0$. This implies that $\Omega^f < 0$ and hence that $H^f < 1$. Also $\Omega^m > 0$ and hence $H^m > 1$.

The supply of brides takes the form

$$S^{IND}(y_1, \tau_1) = 1 + y_1 - \frac{\tau_1}{H^f - 1}$$

and is increasing in the aggregate income y_1 and increasing in τ_1 (which is the opposite of the dowry). The demand for brides takes the form

$$D^{IND}(y_1, \tau_1) = -y_1 - \frac{\tau_1}{H^m - 1}$$

which is decreasing in the aggregate income y_1 and decreasing in τ_1.

Equilibrium in the marriage market Equilibrium marriage payment which clears the marriage market in the first period is the one that solves $D(y_1, \tau_1^*) = S(y_1, \tau_1^*)$, which in both cases leads to

$$\tau_1^*(y_1) = \frac{(1 - H^f)(1 - H^m)}{H^f - H^m}(1 + 2y_1).$$

Equilibrium quantities are computed by substituting the equilibrium price in the demand or in the supply equation. Equilibrium quantities of marriages is equal to

$$Q(y_1)^{SSA} = \frac{1 + 2y_1 - H^f y_1 - H^m(1 + y_1)}{H^f - H^m}, \qquad Q(y_1)^{IND} = \frac{1 + 2y_1 - H^f(1 + y_1) - H^m y_1}{H^f - H^m}.$$

Proposition 1. *For sufficiently large w^m, aggregate income decreases the number of child marriage in equilibrium in societies in which marriage payments are positive (i.e. bride price), and increases the number of child marriage in equilibrium in societies in which marriage payments are negative (i.e. dowry).*

Proof. See Appendix C. □

Intuitively, our results carry through when the supply curve for brides is flatter (slope $\frac{1}{H^f-1}$ in SSA and $-\frac{1}{H^f-1}$ in India) than the demand curve for brides (slope $-\frac{1}{H^f-m}$ in SSA and $\frac{1}{H^f-m}$ in India, see Figure 1). This happens because a son's income provides insurance to his parents, reducing the absolute value of the option of waiting to marry in the second period and making the change in the equilibrium quantity of marriage when aggregate income changes more reflective of the bride's family's response than of the groom's family's response .

In other words, both the demand and the supply of brides are affected by the aggregate income. The key to why equilibrium quantities are different in different economies is that women's families are less price sensitive then men's families, who can rely on the son's income even after the marriage has occurred.

The model also has a prediction also for the way in which marriage payments should vary with aggregate income.

Proposition 2. *Marriage payments are lower when aggregate income is lower.*

Proof. See Appendix C. □

This finding, particularly in the case of Sub-Saharan Africa, is in line with the literature on firesales, in which assets are liquidated at lower prices during recessions (Shleifer and Vishny, 1992).

2.2 Discussion

We have developed a simple model that can explain how aggregate income shocks, that affect both sides of the marriage market, can lead to the observed outcomes in the data. While the *direction* of the marriage payments and their magnitude depend on the traditional role of women in agriculture, we attribute to cultural norms the fact that such payments can be a way to clear the marriage markets. Moreover, even if the historical gender role affects the direction of the marriage payments, the model allows for a convergence in gender roles across space, so long as the differences in the direction of payments persists as a sustainable way to share the surplus for marriage. In this sense, we see culture as a way of selecting among multiple equilibria (Greif, 1994).

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.[8] For sub-Saharan Africa, we use all

[8] 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

DHS surveys from 1994-2012 where GPS (geographical positioning system) data are available, resulting in a total of 72 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.[9]

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.[10] 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 and 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.

Last, in the light of the evidence on rainfall and intensity of civil conflict (Miguel, Satyanath, and Sergenti, 2004), we exclude women exposed to major civil conflicts between ages 10 and 17, using data from UCDP/PRIO Armed Conflict Dataset.[11]

After making the restrictions described here, our final sample consists of about 235,000 women in sub-Saharan Africa, and 63,000 women in India.

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 it features primarily panel information, and hence does not add a large number of observations to our sample.

[9] 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.

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

[11] For our sample period and countries, the dataset reports the following civil conflicts: Burundi 1994-2006, Cameroon 1960-1961, Congo DR 1964-1965 and 1996-2001, Ethiopia 1964-1991, Kenya 1952-1956, Liberia 2000-2003, Madagascar 1947, Mozambique 1964-1974 and 1977-1992, Nigeria 1967-1970, Uganda 1979-1992 and 1994-2011, Rwanda 1990-1994, 1996-2002 and 2009-onward, Sierra Leone 1991-2001 and Zimbabwe 1973-1979.

Table 1 presents summary statistics for our main sample of women (i.e. aged 25 and older at the time of interview). 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.

Figure 2 plots the distribution of ages of marriage in our data. In both regions, the hazard into early marriage is relatively 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, that usually occurs sometime in the early teenage years (see Field and Ambrus, 2008).

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; Burke, Gong, and Jones, 2014; Shah and Steinberg, forthcoming). 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.[12] For Africa, we use the GPS information in the DHS 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 3,000 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 drought as calendar year rainfall below the 15th percentile of a location's (grid cell or district) long-run rainfall distribution, and a 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.

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

[12] 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 an overview of the UDel data and other global weather data sets, see Dell, Jones, and Olken (2013).

tion, 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 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 yields of the main staple crops in the continent: maize (the most important), rice, wheat, soghum and millet. We also estimate the impact of shocks on yields for all the cereals included in our dataset (which includes maize, rice, wheat, soghum, millet, barley, rye, oats, buckwheat, fonio, triticale and canary seeds). 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 flood) in the same manner used in the main analysis.

As shown in table Table 2, drought (rainfall below the 15th percentile) reduces maize, rice, wheat, soghum and millet yield. In columns 9-10 of table Table 2, we show that drought reduce average cereals yields by 12 and 11 percent, respectively. Flood (rainfall above the 85th percentile) is estimated to improve cereal yields by 4.1 and 3.7 percent respectively. We also estimate a local linear regression of the relationship between rainfall percentile and cereal yields, the results of which are shown in Appendix A. 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).

For India, we rely on district-level yield data from the World Bank India Agriculture and Climate Dataset from 1956 to 1987.[13] 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, maize, wheat, bajra, and sesamum), as well as on all the staple crops in our dataset (rice, maize, wheat, bajra, sesamum, ragi, jowar, sunflower). As shown in Table 3, drought negatively affects yields of all crops, and is estimated to reduce yields by 9.1% overall. Flood, on the other hand, has positive

[13] The advantage of using the World Bank India Agriculture and Climate Dataset over FAOStat database is that it provides crop yields by district.

effects for rice yields and negative or zero effects for other staples, resulting in a null impact on yields overall. This finding is supported by the local linear regression results in Figure A2. The fact that flood has no real positive or negative impact on yields helps explain the fact that, in our main analysis, flood 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. Floods are a moderate proxy for positive income, particularly in sub-Saharan Africa.

A major concern with our empirical strategy is that our constructed weather shocks may be correlated with the underlying climatological conditions of a particular location, such as the propensity to experience extreme weather realizations, which in turn could have important impacts on local infrastructure and/or general poverty levels and thus on marriages. In Figure B1 we plot the percentage of grid cells (for SSA) and districts (for India) exposed to weather shocks by calendar year. Given that droughts and floods are defined as a variation in rainfall below and above the 15th and 85th percentile, the average probability of experience a shocks in each region is around 15%. Most importantly, Figure B1 provides evidence 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 duration model, adapted from Currie and Neidell (2005). 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.

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

$$M_{i,g,k,t} = \beta' X_{g,k,t} + \alpha_t + \omega_g + \gamma_k + \epsilon_{i,g,k,t}. \quad (1)$$

The dependent variable, $M_{i,g,k,t}$ is a binary variable coded as 1 in the year the woman gets married, and zero otherwise. 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.[14] In this equation, $X_{g,k,t}$ are time-varying measures of weather conditions in location g during the year in which the woman born in year k is age t. Specifically, included in $X_{g,k,t}$ are a dummy indicator for a drought in a given year, and a dummy indicator for a flood in that year. β are the main coefficients of interest and measure the effect of rainfall shocks on the probability of marriage. α_t is age fixed effect, a measure of duration dependence and control for the fact that marriage has a different probability to happen, for example at 10 or at 17 year old. We include location-specific fixed effects, ω_g, to control for time-invariant unobservables at the location level (i.e. richer versus poorer location), and year-of-birth fixed effects γ_k to account for cohort effects.[15] Each time-invariant covariate is repeated for every period, and time-varying covariates (the weather shocks) are updated each period. Since we are combining data across multiple survey instruments, we use population-weighted survey weights to make results representative of 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 serial correlation in error terms across individuals in the same area.

With the inclusion of location (grid cell or district) and year of birth fixed effects, the impact of weather shocks on the early marriage hazard is identified from within-location and within year of birth variation in weather shocks and marriage outcomes. The key identifying assumption of the analysis is that, within a given location and year of birth, the weather shocks included in $X_{g,k,t}$ are orthogonal to potential confounders. As discussed in Section 3, this should be true given the way these variables are 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

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

[15]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 are 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.

retrospective nature of our analysis, there are many unobservables for which we cannot control. 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)).

Another potential threat to identification comes from the fact that we are considering weather shocks in the current place of residence. Indeed, 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 one relates to the custom of patrilocal exogamy. In India and in many parts of Africa, societies are patrilocal, meaning that a daughter joins the household of the groom and his family at the time of marriage. Thus, due to patrilocal exogamy, women move 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. 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 rbeduces 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 a recent work by Fulford (2013), who shows that inter-household transfers from daughters to parents 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. While patrilocality is common in both regions, the available data on marriage migration indicates that most married women do not move far from their natal home.

In the set of African countries we study in our analysis, marriage migration is not prevalent at all. Table 4, Panel A, column 1, shows that more than 40% of women report never moving from their natal home. Furthermore, when it does occur, previous literature suggests that happens across relatively short distances. Mbaye and Wagner (2013) collect data in Senegal and find that women live an average of 20 kilometers from their natal home, while our cells measure approximately 2,500 squared kilometers at Equator. In India, 58.02% of women migrated at the time of marriage, but again migration happens at close distances, or in any case, within geographic area at which we define our rainfall shocks. In the the IHDS, the average travel time between a woman's current residence and her natal home is about 3 hours and 6 hours for the

90% of the respondents (see Table 4, panel B). In Rosenzweig and Stark's ICRISAT data, the average distance between a woman's current place of residence and her natal home is 25km.

Second, even after marriage, the household may have migrated to another village. In Atkin (2016), according to the 1983 and the 1987-88 Indian National Sample Surveys (NSS), only 6.1 percent of households are classified as migrant households, defined as households where the enumeration village differs from the household member's last usual residence. Only a small percentage of women move after marriage and even if they migrate, they do not move very far away. Furthermore, 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.

Altogether, the available information on marriage migration in Africa and India suggests 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 identification strategy.

Finally, 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

5 Results

In this section, we describe our main empirical findings.

5.1 Main results

Table 5 displays results of Equation (1), estimated separately on the data for Africa and India. Drought - a 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. In term of magnitude, we find that drought reduces the early marriage hazard by 0.23 percentage points in Africa (Column 3), and increases the early marriage hazard by 0.45 percentage points in India (Column 6). Flood appears to reduce the early marriage hazard in sub-Saharan Africa (by 0.25 percentage points) but not in India, which is not surprising given that we show that our constructed flood measure has relatively muted effects on crop yields.

5.2 By prevalence of bride price in sub-Saharan Africa

We now turn to test whether marriage payments do play a role in explaining the effect of rainfall shocks on early marriages. We exploit heterogeneity in marriage payments across ethnic groups in different countries. Our data source for measures of traditional marriage customs in different ethnic groups is George Peter Murdock's (1967) *Ethnographic Atlas.* The Atlas provides information on transfers made at marriage, either bride price or dowry, by ethnic groups.

In Table 6, we report the estimated effects of rainfall shocks in sub-Saharan African countries with a share of individuals historically belonging to ethnic groups with bride price prevailing norms higher than 50% and 80%, based on *Ethnomaps* (see A3), which combines the *Ethnographic Atlas* with population data at the ethnic group level. Countries with a bride price prevalence equal or greater than 50% include all SSA countries except Madagascar, Malawi, Mozambique and Zambia. Countries with a bride price prevalence equal or greater than 80% include all SSA ountries except Madagascar, Malawi, Mozambique, Zambia, CAR, Ivory Coast, Ethiopia, Gabon, Namibia and Togo.

Table 6 shows that the effect of drought on the early marriage hazard is higher for countries that have a high prevalence of bride price payment.

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 each age dummy between age 10 and age 17.

Figure 3 reports the results of the analysis. We see that the effects of drought are concentrated around age 16 in both countries.

5.4 By ethnic group

In table Table 7 , we test the effect of rainfall shocks on early marriage in Zambia, a country in SSA where there is substantial heterogeneity by ethnic groups in bride price payment. Following Ashraf, Bau, Nunn, and Voena (2016), we merge the ethnic group of the respondent in the

Zambia DHS with the Murdock's (1967) *Ethnographic Atlas*. We show that, even within the same country, the effect of rainfall shock is concentrated among groups that traditionally engage in bride price payments. Specifically, floods increase early marriage in Zambia by 1.1 percentage points but only in groups that traditionally engage in bride price payments (column 4). Estimates on droughts lack precision in this smaller sample.

5.5 By credit availability in India

We examine whether the effect of rainfall shocks varies with the development of the banking sector at the district level in India. Following Jayachandran (2006), we use district-level data on the number of bank branches in each district as a proxy for credit markets development. We refer to Burgess, Pande, and Wong (2005) and Jayachandran (2006) for a discussion of this source of variation. We measure the number of bank branches in rural areas of each district per 1,000 inhabitants (with mean 0.025, and standard deviation 0.065), and the number of bank branches in total in each district per 1,000 inhabitants (with mean 0.067, and standard deviation 0.026). Our results suggests that access to credit and savings in rural areas greatly reduces the impact of droughts on the timing of marriage (table 8, column 1 and 2).

6 Additional evidence and robustness

In this section, we present a set of empirical findings and robustness checks.

6.1 Effects on early fertility

In table 11, we examine how droughts and floods affect the onset of fertility, by replacing the marital outcome with the birth of the first child. As expected when marriage occurs early, we find that droughts also lead women to have children earlier in Sub-Saharan Africa, with a 0.019 percentage points increase in the annual hazard of having the first child below age 18, corresponding to a 4.3% increase. Floods do not have statistically significant effects in SSA. We find no effects of rainfall shocks on the timing of fertility in India, where we use data only from the DHS on age at first birth.

6.2 Characteristics of the marriage by weather realization

To examine the characteristic of women who marry during years of drought and flood, we examine the following specifications, woman i living in location g (grid cell in Africa, district in India) born in cohort k and married in year τ as follows:

$$y_{i,g,k,\tau} = \beta' X_{g,k,\tau} + \delta_\tau + \omega_g + \gamma_k + \zeta_i + \epsilon_{i,g,k,\tau}. \tag{2}$$

In this specification, $X_{g,k,\tau}$ are time-varying measures of weather conditions in location g during the year in which the woman marries τ. We control location fixed effects ω_g, for current age (at the time of the survey) fixed effects ζ_i, for year of birth γ_k, and for year of marriage δ_τ. It is important to notice that we cannot assign any causal interpretation to these estimated, as they are the result of both selection and causal forces.

In Sub-Saharan Africa, we find that the women who marry during droughts tend to marry men of similar ages as those who marry during regular times (table 12, column 1). The are not more likely to be in polygynous marriages, but may be slightly more likely to be a first wife in a polygynous union, possibly because of the earlier marriage (columns 2 and 3). They are also more likely to be uneducated, but not more likely to ma matched to an uneducated man (columns 4 and 5). Finally, they have less say in household decision making compared do their husband (columns 6 and 7).

In the India 1998 DHS, we can use the same available variable to examine these outcomes (table 13). Fewer variables are available in the India DHS compared to the sub-Saharan African ones, and in particular we lack information bout women's say in the household. We find that while gender age gaps seem to widen during droughts, it is a very small increase by 0.15 years with respect to an average age gap of over 6 years. We do not find that the education of spouses who marry during droughts are different from those of the other couples.

An implication of our model is that matches that form during droughts should command lower payments. To study this implication, we examine an additional data source, the 1998 wave of the Rural Economic and Demographic Survey (REDS), which features information about the dowry paid for respondents' daughters. Following Roy (2015), we define as dowry paid the gross amounts paid, and we express it real terms (2010 Indian Rupees). In this sample, the mean payment is equal to 77,306 INR, with a standard deviation of 195,034. As shown in table 14, there is a negative association between dowry paid and marriages occurring during droughts, which are around 20% lower than baseline. This finding is consistent with proposition 2, but may also be due to a differential selection of women into marriage. While controlling for spouses' age of marriage (columns 2 and 6), spouses' education (columns 3 and 7) and parents' education (columns 4 and 8) does not substantially change our estimates, we lack other information about the bride's and the groom's characteristics.

6.3 Alternative measures of weather shocks

As a further robustness check, we investigate how the impact of drought varies with the definition of our drought measure. We use two approaches. First, we re-estimate our main regression equation for varying cutoff levels to determine drought, ranging from the 5th percentile to the 45th percentile. Figure 4 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 our main regression equation with indicators for the top and the bottom rainfall quintiles between 1960 and 2010. Effects for the bottom quintile of rainfall are comparable to our measure of drought (see table Table A5).

7 Indonesia (preliminary)

To examine the validity of our interpretation in a new context, we move the analysis to Indonesia, an Asian country that has an ancient bride price tradition among 46% of all ethnic groups (Murdock, 1967), as documented in Ashraf, Bau, Nunn, and Voena (2016). We use data from the 3rd and 4th rounds of the Indonesia Family Life Survey (IFLS), a dataset with rich information about marriage and migration history. Figure 5 reports the distribution of ages at marriage for women aged 25 and above at the time of the interview. In this sample, 31% of women marry before age 18.

We merge the UDel data aggregated at the level of province to the 21 provinces of birth of

7,857 female respondents in the IFLS, and expand the dataset to maintain the same specification discussed above for SSA and India. The availability of information on the province of birth is an additional advantage of the IFLS dataset.

By replicating our analysis in this new context, we find that a drought is associated with a 0.5 percentage points increase in the annual hazard of child marriage (table 16, columns 1 and 2), with a baseline hazard of 4.2 (table 15). Following Ashraf, Bau, Nunn, and Voena (2016), we combine our merged data to Murdock's *Ethnographic Atlas* to identify respondents who belong to ethnic groups that traditionally engage in bride price payments. We show that effects are concentrated among these groups (table 16, columns 3 and 4).

8 Conclusions

This paper presents empirical results showing that negative weather shocks, which proxy for aggregate negative income shocks, have opposite effects on the probability of child marriage in sub-Saharan 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 may need to account for local customs and practices to be effective.

References

ALESINA, A., Y. ALGAN, P. CAHUC, AND P. GIULIANO (2010): "Family Values and the Regulation of Labor," NBER Working Paper 15747.

ALESINA, A., P. GIULIANO, AND N. NUNN (2013): "On the Origins of Gender Roles: Women and the Plough," *Quarterly Journal of Economics*, 128(2), 469–530.

ALGAN, Y., AND P. CAHUC (2010): "Inherited Trust and Growth," *American Economic Review*, 100(5), 2060–2092.

ANDERSON, S. (2003): "Why Dowry Payments Declined With Modernization in Europe but are Rising in India," *Journal of Political Economy*, 111(2), 269–310.

——— (2007): "The Economics of Dowry and Brideprice," *Journal of Economic Perspectives*, 21(4), 151–174.

ANDERSON, S., AND C. BIDNER (2015): "Property Rights Over Marital Transfers," Quarterly Journal of Economics.

ANGELUCCI, M., G. DE GIORGI, M. A. RANGEL, AND I. RASUL (2010): "Family networks and school enrolment: Evidence from a randomized social experiment," *Journal of public Economics*, 94(3), 197–221.

ASHRAF, N., N. BAU, N. NUNN, AND A. VOENA (2016): "Bride price and female education," Unpublished Manuscript.

ATKIN, D. (2016): "The caloric costs of culture: Evidence from Indian migrants," *The American Economic Review*, 106(4), 1144–1181.

BANK, W. (2014): "Untying the Knot: Exploring Early Marriage in Fragile States," .

BECKER, G. (1991): *A Treatise on the Family*. Enlarged edition, Cambridge, MA: Harvard University Press.

BLOCH, E., AND V. RAO (2002): "Terror as a Bargaining Instrument: Dowry violence in rural India," *American Economic Review*, 92(4), 1029–1043.

Boserup, E. (1970): *Woman's Role in Economic Development*. George Allen and Unwin Ltd., London.

Botticini, M. (1999): "A Loveless Economy? Intergenerational Altruism and the Marriage Market in a Tuscan Town, 1415-1436," *The Journal of Economic History*, 59, No. 1, 104–121.

Botticini, M., and A. Siow (2003): "Why Dowries?," *The American Economic Review*, 93, No. 4, 1385–1398.

Burgess, R., R. Pande, and G. Wong (2005): "Banking for the poor: Evidence from India," *Journal of the European Economic Association*, 3(2-3), 268–278.

Burke, M., E. Gong, and K. Jones (2014): "Income Shocks and HIV in Africa," *Economic Journal (forthcoming)*.

Caldwell, J., P. Reddy, and P. Caldwell (1983): "The Causes of Marriage Change in South India," *Population Studies*, 37(3), 343–361.

Chowdhury, A. (2010): "Money and Marriage: The Practice of Dowry and Brideprice in Rural India," presented at the Population Association of America 2010 Annual Meeting: Dallas, Texas.

Corno, L., and A. Voena (2016): "Selling daughters: age of marriage, income shocks and bride price tradition," Unpublished Manuscript.

Currie, J., and M. Neidell (2005): "Air Pollution and Infant Health: What Can We Learn from California's Recent Experience," *Quarterly Journal of Economics*, 120(3), 1003–1030.

De Weerdt, J., and S. Dercon (2006): "Risk-sharing networks and insurance against illness," *Journal of development Economics*, 81(2), 337–356.

Decker, M., and H. Hoogeveen (2002): "Bridewealth and Household Security in Rural Zimbabwe," *Journal of African Economies*, 11(1), 114–145.

Dell, M., B. Jones, and B. Olken (2012): "Temperature Shocks and Economic Growth: Evidence from the Last Half Century," *American Economic Journal: Macroeconomics*, 4(3), 66–95.

——— (2013): "What Do We Learn from the Weather? The New Climate-Economy Literature," *Journal of Economic Literature (forthcoming)*.

Dercon, S. (2002): "Income risk, coping strategies, and safety nets," *The World Bank Research Observer*, 17(2), 141–166.

Fafchamps, M., and F. Gubert (2007): "Risk sharing and network formation," *The American economic review*, 97(2), 75–79.

Fafchamps, M., C. Udry, and K. Czukas (1998): "Drought and saving in West Africa: are livestock a buffer stock?," *Journal of Development economics*, 55(2), 273–305.

Fernandez, R., and A. Fogli (2009): "Culture: An Empirical Investigation of Beliefs, Work, and Fertility," *American Economic Journal: Macroeconomics*, 1(1), 146–177.

Fernandez, R., A. Fogli, and C. Olivetti (2004): "Mothers and Sons: Preference Formation and Female Labor Force Dynamics," *Quarterly Journal of Economics*, 119(4), 1249–1299.

Field, E., and A. Ambrus (2008): "Early Marriage, Age of Menarche and Female Schooling Attainment in Bangladesh," *Journal of Political Economy*, 116(5), 881–930.

Fulford, S. (2013): "The Puzzle of Marriage Migration in India," Working Paper (October).

Giuliano, P. (2014): "The Role of Women in Society: from Pre-Industrial to Modern Times," *CESifo Economic Studies*, forthcoming.

Goody, J. (1976): *Production and Reproduction*. Cambridge University Press, Cambridge, UK.

Goody, J., and S. Tambiah (1973): *Bridewealth and Dowry*. Cambridge University Press, Cambridge.

Greif, A. (1994): "Cultural beliefs and the organization of society: A historical and theoretical reflection on collectivist and individualist societies," *Journal of political economy*, pp. 912–950.

Jacoby, H. G. (1995): "The Economics of Polygyny in Sub-Saharan Africa: Female Productivity and the Demand for Wives in Côte d'Ivoire," *Journal of Political Economy*, 103, No. 5, 938–971.

Jayachandran, S. (2006): "Selling Labor Low: Wage Responses to Productivity Shocks in Developing Countries," *Journal of Political Economy*, 114(3), 538–575.

Jensen, R., and R. Thornton (2003): "Early Female Marriage in the Developing World," *Gender and Development*, 11(2), 9–19.

La Ferrara, E. (2007): "Descent Rules and Strategic Transfers. Evidence from Matrilineal Groups in Ghana," *Journal of Development Economics*, 83 (2), 280–301.

La Ferrara, E., and A. Milazzo (2012): "Customary Norms, Inheritance and human capital: evidence from a reform of the matrilineal system in Ghana," *working paper*.

Mbaye, L., and N. Wagner (2013): "Bride Price and Fertility Decisions: Evidence from Rural Senegal," IZA Discussion Paper No. 770 (November).

Miguel, E., S. Satyanath, and E. Sergenti (2004): "Economic Shocks and Civil Conflict: An Instrumental Variables Approach," *Journal of Political Economy*, 112 (41)), 225–253.

Morten, M. (2016): "Temporary migration and endogenous risk sharing in village india," Discussion paper, National Bureau of Economic Research.

Murdock, G. P. (1967): *Ethnographic Atlas*. University of Pittsburgh Press, Pittsburgh.

Nunn, N., and L. Wantchekon (2011): "The slave trade and the origins of mistrust in Africa," *The American Economic Review*, 101(7), 3221–3252.

Rao, V. (1993): "The rising price of husbands: A hedonic analysis of dowry increases in rural India," *Journal of Political Economy*, pp. 666–677.

Rosenzweig, M. R., and O. Stark (1989): "Consumption smoothing, migration, and marriage: Evidence from rural India," *The Journal of Political Economy*, pp. 905–926.

Roy, S. (2015): "Empowering women? Inheritance rights, female education and dowry payments in India," *Journal of Development Economics*, 114, 233–251.

Sautmann, A. (2012): "Partner Search and Demographics: The Marriage Squeeze in India," Working Paper (July).

Schlenker, W., and D. Lobell (2010): “Robust Negative Impacts of Climate Change on African Agriculture,” *Environmental Research Letters*, 5, 01410.

Shah, M., and B. M. Steinberg (forthcoming): “Drought of opportunities: contemporaneous and long term impacts of rainfall shocks on human capital,” *Journal of Political Economy*.

Shleifer, A., and R. Vishny (1992): “Liquidation Values and Debt Capacity: A Market Equilibrium,” *The Journal of Finance*, XLVII(4), 1343–1366.

Tabellini, G. (2010): “Culture and institutions: economic development in the regions of Europe,” *Journal of the European Economic Association*, 8(4), 677–716.

Tertilt, M. (2005): “Polygyny, fertility, and savings,” *Journal of Political Economy*, 113(6), 1341–1371.

Townsend, R. M. (1994): “Risk and insurance in village India,” *Econometrica: Journal of the Econometric Society*, pp. 539–591.

Vogl, T. (2013): “Marriage Institutions and Sibling Competition: Evidence from South Asia,” *Quarterly Journal of Economics*, 128(3), 1017–1072.

World Bank (2015): *World Development Report 2015: Mind, Society, and Behavior*. World Bank Publications, Washington, D.C.

Worldvision (2013): “Voice and Agency: Empowering Women and Girls for Shared Prosperity,” .

Figure 1: Equilibrium outcomes

(a) Sub-Saharan Africa (b) India

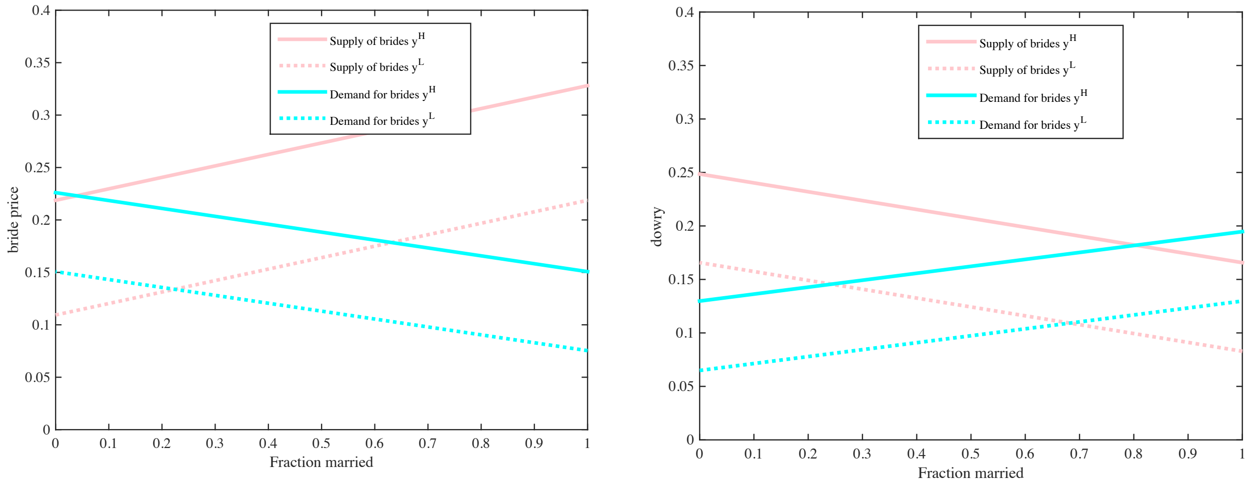
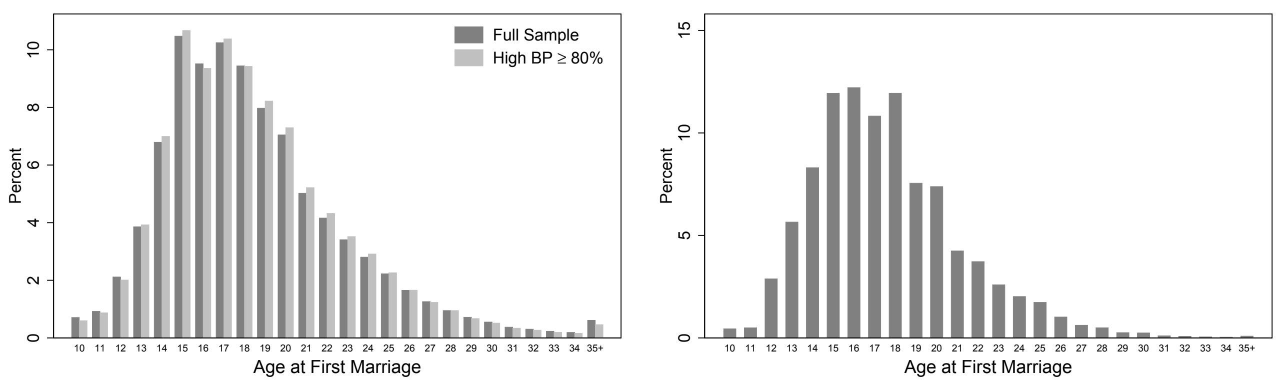


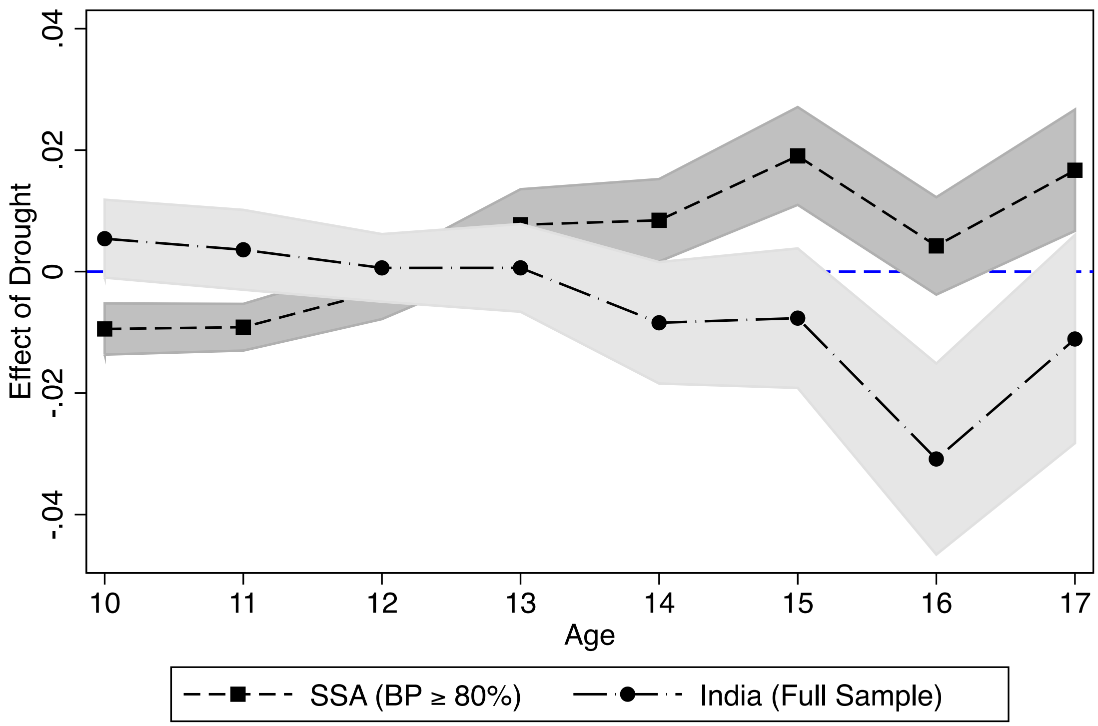
Figure 2: Distribution of the Ages at First Marriage

(a) SSA (b) India



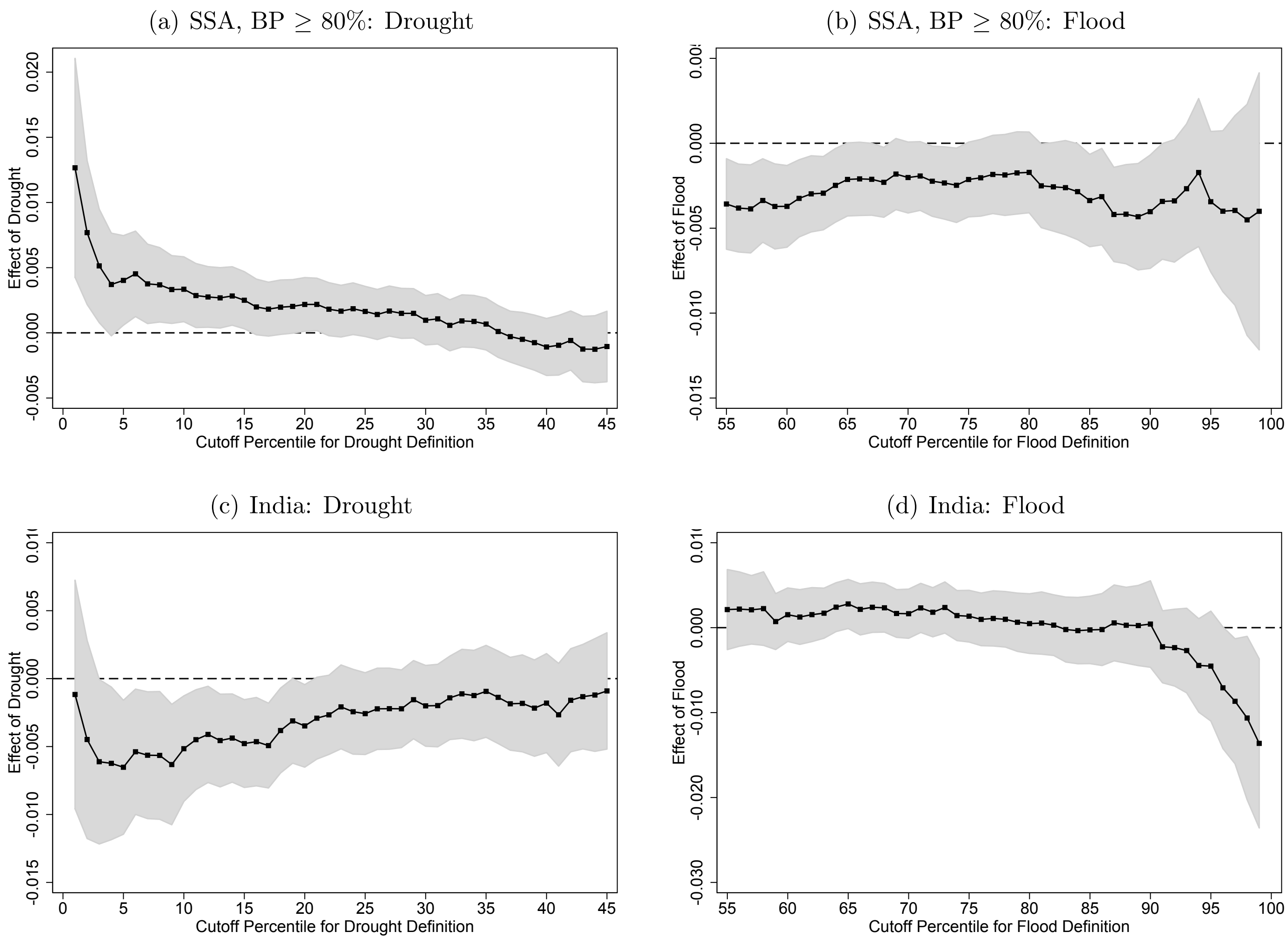
Note: Figures show the distribution of ages at first marriage for individuals in our main analysis samples: surveyed women aged 25 or above at the time of interview. Those who were not married are not shown as a separate category in these plots, but they were included in the denominator of the calculation of these percentages.

Figure 3: Effect of Drought on Marriage by Age



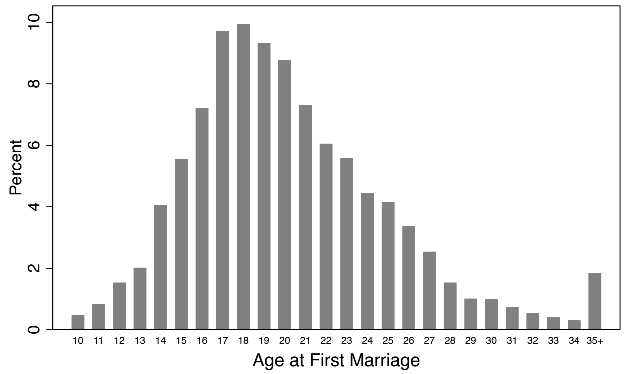
Note: Figure shows the effect of drought by age estimated using the high bride price (BP) Sub-Saharan Africa (SSA) and full India regression samples. The lines show the estimated coefficients and the gray bands show the 95% confidence intervals. The corresponding estimates are presented in Table A4.

Figure 4: Robustness in Drought and Flood Definitions Based on Cutoffs in Rainfall Distribution



Note: Figures show the point estimates of the effect of drought and flood on early marriages, estimated using OLS regressions for the high bride price (BP) Sub-Saharan Africa (SSA) and full India regression samples: women aged 25 or older at the time of interview. The different points represent different definitions of drought and flood based on the percentile of rainfall in a grid cell (SSA) or district (India) in a given year, relative to the modeled long run rainfall (gamma) distribution in that grid cell or district. The gray bands show the 95% confidence intervals of the estimated coefficients. For all the analyses in this paper, for any grid cell or district, we define a drought as having rainfall lower than the 15^{th} percentile of the long-run rainfall distribution, and a flood as having rainfall greater than the 85^{th} percentile of the same distribution.

Figure 5: Distribution of the Ages at First Marriage in Indonesia



Note: Figures show the distribution of ages at first marriage for individuals in our IFLS analysis samples: surveyed women aged 25 or above at the time of interview. Those who were not married are not shown as a separate category in these plots, but they were included in the denominator of the calculation of these percentages.

Table 1: Summary Statistics for Regression Samples: Sub-Saharan Africa and India

	SSA			India		
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Panel A: Full Sample						
Unique Individuals in Sample	343,947			97,812		
Percent Married Between Ages 10-17	2,460,543	6.60	24.83	540,130	10.01	30.02
Percent Drought	2,460,543	16.47	37.09	540,130	15.57	36.26
Percent Flood	2,460,543	11.56	31.97	540,130	16.32	36.96
Birth Year	2,460,543	1,971.50	8.35	540,130	1,967.86	7.31
Age	2,460,543	13.19	2.22	540,130	13.41	2.09
Panel B: High BP ($\geq$ 80%) Countries						
Unique Individuals in Sample	244,006					
Percent Married Between Ages 10-17	1,727,772	6.70	25.01			
Percent Drought	1,727,772	16.47	37.09			
Percent Flood	1,727,772	10.95	31.22			
Birth Year	1,727,772	1,971.58	8.09			
Age	1,727,772	13.18	2.22			

Note: Table shows summary statistics for the main Sub-Saharan Africa (SSA) and India regression samples: women aged 25 or older at the time of interview. Observations are at the level of person $\times$ age (from 10 to 17 or age of first marriage, whichever is earlier). Statistics are weighted to be representative of the included countries (SSA) or districts (India).

Table 2: Weather Shocks and Crop Yields in Sub-Saharan Africa

	(1) Maize All SSA	(2) Maize DHS	(3) Wheat All SSA	(4) Wheat DHS	(5) Sorghum All SSA	(6) Sorghum DHS	(7) Millet All SSA	(8) Millet DHS	(9) Avg All SSA	(10) Avg DHS
Drought	-0.117***	-0.120***	-0.059	-0.056	-0.122***	-0.095**	-0.070**	-0.066**	-0.124***	-0.112***
	(0.027)	(0.028)	(0.036)	(0.047)	(0.038)	(0.042)	(0.032)	(0.031)	(0.025)	(0.026)
Flood	0.039	0.050*	0.045	0.023	0.039*	0.017	0.029	0.036*	0.041**	0.037
	(0.028)	(0.030)	(0.038)	(0.030)	(0.020)	(0.019)	(0.021)	(0.021)	(0.020)	(0.024)
R^2	0.590	0.518	0.653	0.679	0.656	0.684	0.663	0.677	0.753	0.755
Obs	1,850	1,450	1,253	906	1,693	1,383	1,593	1,233	1,818	1,450

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

Note: Dependent variable is the log of annual crop yield (hectograms per ton) 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. Average yields in cols. 9-10 is the log of the sum of the total production of the main crops reported (rice, maize, wheat, sorghum and milled) divided by the area harvested for those crops. Standard errors, clustered at the country level, are reported in parentheses.

Table 3: Weather Shocks and Crop Yields in India

	(1) Rice	(2) Maize	(3) Wheat	(4) Bajra	(5) Jowar	(6) Average yield
Drought	-0.179***	-0.051***	-0.047***	-0.215***	-0.197***	-0.163***
	(0.019)	(0.018)	(0.014)	(0.026)	(0.022)	(0.015)
Flood	0.060***	-0.136***	-0.000	-0.051**	-0.072***	0.006
	(0.010)	(0.018)	(0.011)	(0.021)	(0.017)	(0.010)
R2	0.684	0.399	0.704	0.594	0.556	0.808
Obs	7,182	6,720	6,730	5,276	6,418	7,583

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

Note: Note: Dependent variable is the log of annual crop yield (hectograms per ton) for each district from 1957-1987. Average yields in col 6 is the log of the sum of the total production of the main crops reported (rice, maize, wheat, sorghum and milled) divided by the area harvested for those crops. Yield data are from the World Bank India Agriculture and Climate Data set. Regressions include year and district fixed effects. Standard errors, clustered at the district level, are reported in parentheses.

Table 4: Marriage migration in Africa and in India

Panel A: Data from DHS				
	Never migrated	Migrated before marriage	Migrated at marriage	Migrated after marriage
SSA	41.04%	7.39%	22.96%	28.61%
India	13.21%	9.16%	58.02%	19.62%
Panel B: Data from IHDS				
	Distance to wife's natal home (hrs)			
	Mean	Median	75th percentile	90th percentile
India	3.44	5.79	4.00	6.00

Notes: Panel A shows how long ever-married women 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.

Table 5: Effect of Weather Shocks on Early Marriages

	SSA			India	
	(1)	(2)	(3)	(4)	(5)
Drought	0.0023**	0.0023**	0.0017*	-0.0048***	-0.0045***
	(0.00096)	(0.00096)	(0.00095)	(0.0016)	(0.0017)
Flood	-0.0025**	-0.0025**	-0.0026**	-0.000019	0.00038
	(0.0011)	(0.0011)	(0.0011)	(0.0020)	(0.0021)
Birth Year FE	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	No	No
Country FE × Cohort FE	No	No	Yes	No	No
District FE × Cohort FE	No	No	No	No	Yes
N	2,460,543	2,460,543	2,460,543	679,222	679,222
Adjusted R^2	0.076	0.076	0.077	0.10	0.10

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for the full Sub-Saharan Africa (SSA) and India regression samples: women aged 25 or older at the time of interview. Observations are at the level of person × age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the grid cell level in columns 1-3 and the district level in columns 4-5. All regression specifications include grid cell (SSA) or district (India) fixed effects. Results are weighted to be representative of the included countries (SSA) or districts (India).

Table 6: Effect of Weather Shocks on Early Marriages, by Bride Price Custom in Sub-Saharan-Africa

	Full Sample	BP $\geq$ 50%		BP $\geq$ 80%	
	(1)	(2)	(3)	(4)	(5)
Drought	0.0023**	0.0025**	0.0025**	0.0026**	0.0026**
	(0.00096)	(0.0010)	(0.0010)	(0.0011)	(0.0011)
Flood	-0.0025**	-0.0026**	-0.0026**	-0.0032**	-0.0032**
	(0.0011)	(0.0013)	(0.0013)	(0.0014)	(0.0014)
Birth Year FE	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	No	Yes	No	Yes
N	2,460,543	2,061,802	2,061,802	1,727,772	1,727,772
Adjusted R^2	0.076	0.077	0.077	0.078	0.078

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for Sub-Saharan Africa (SSA): women aged 25 or older at the time of interview. Column 1 presents the full sample results, while the other columns present results for SSA countries with high prevalence of bride price (BP) custom, defined based on thresholds of 50% (columns 2-3) and 80% (columns 4-5). Observations are at the level of person $\times$ age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the grid cell level. All regression specifications include grid cell fixed effects. Results are weighted to be representative of the included countries. See Table A3 for traditional marriage customs by country.

Table 7: Effect of Weather Shocks on Early Marriages in Zambia, by Traditional Bride Price Practice of the Ethnic Group

	(1) Zambia	(2) Zambia	(3) Zambia in EA	(4) Zambia, BP	(5) Zambia, no BP
Drought	0.0011	0.0012	0.0015	0.0027	0.0010
	(0.0021)	(0.0022)	(0.0021)	(0.0037)	(0.0025)
Flood	-0.0027	-0.0025	-0.0024	-0.011**	0.0013
	(0.0029)	(0.0030)	(0.0029)	(0.0045)	(0.0039)
Birth Year FE	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes
Grid cell FE × Cohort FE	No	Yes	Yes	Yes	Yes
N	100,714	100,714	97,869	28,774	69,095
Adjusted R^2	0.081	0.082	0.083	0.084	0.083

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for Zambia: women aged 25 or older at the time of interview. Observations are at the level of person × age (from 10 to 17 or age of first marriage, whichever is earlier). The data is merged with Murdock's *Ethnographic Atlas* (1957). See Ashraf et al. (2016) for a description of the ethnic concordance. Robust standard errors (in parentheses) are clustered at the grid cell level. All regression specifications include grid cell fixed effects. Results are weighted to be representative of the included countries.

Table 8: Effect of Weather Shocks on Early Marriages, by Bank Development in India

	Full Sample			
	(1)	(2)	(3)	(4)
Drought	-0.011†	-0.0098***	-0.011†	-0.0096***
	(0.0028)	(0.0030)	(0.0030)	(0.0031)
Flood	-0.0040	-0.0031	-0.0036	-0.0023
	(0.0049)	(0.0051)	(0.0042)	(0.0043)
Drought * Rural branches per cap	0.11*	0.067		
	(0.064)	(0.067)		
Flood * Rural branches per cap	0.17	0.15		
	(0.12)	(0.13)		
Rural branches per cap	0.21*	-0.032		
	(0.11)	(0.19)		
Drought * Num. of branches per cap			0.040	0.022
			(0.024)	(0.024)
Flood * Num. of branches per cap			0.061	0.045
			(0.037)	(0.037)
Num. of branches per cap			0.054	-0.21***
			(0.044)	(0.077)
Birth Year FE	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes
District FE × Cohort FE	No	Yes	No	Yes
N	289,046	289,046	289,046	289,046
Adjusted R^2	0.091	0.094	0.091	0.094

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for India: women aged 25 or older at the time of interview. Observations are at the level of person × age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the grid cell level. Bank development data is from Jayachandran (2006). Per capita variables are multiplied by 1,000. All regression specifications include grid cell fixed effects. Results are weighted to be representative of the included surveys.

Table 9: Effect of Current and Lag Weather Shocks on Early Marriages

	SSA		India	
	(1)	(2)	(3)	(4)
Drought	0.0021**		-0.0057***	
	(0.00096)		(0.0019)	
Drought Lag 1	0.00023		-0.00027	
	(0.00100)		(0.0020)	
Any Drought in Current & Last Years		0.0020**		-0.0029*
		(0.00082)		(0.0015)
Flood	-0.0026**		-0.00028	
	(0.0011)		(0.0023)	
Flood Lag 1	-0.0034***		0.00052	
	(0.0011)		(0.0019)	
Any Flood in Current & Last Years		-0.0028***		0.0016
		(0.00099)		(0.0019)
Birth Year FE	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	No	No
N	2,457,280	2,457,280	540,053	540,053
Adjusted R^2	0.076	0.076	0.094	0.094

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for the full Sub-Saharan Africa (SSA) and India regression samples: women aged 25 or older at the time of interview. Observations are at the level of person × age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the grid cell level (SSA) or district level (India). All regression specifications include grid cell (SSA) or district (India) fixed effects. Results are weighted to be representative of the included countries (SSA) or districts (India).

Table 10: Effect of Current and Lag Weather Shocks on Early Marriages: High Bride Price Sub-Saharan Africa Sample

	(1)	(2)	(3)	(4)
Drought	0.0023**	0.0023**		
	(0.0011)	(0.0011)		
Drought Lag 1	0.0011	0.0010		
	(0.0012)	(0.0012)		
Any Drought in Current or Last Year			0.0025***	0.0025***
			(0.00096)	(0.00096)
Flood	-0.0033**	-0.0033**		
	(0.0014)	(0.0014)		
Flood Lag 1	-0.0046†	-0.0046†		
	(0.0014)	(0.0014)		
Any Flood in Current or Last Year			-0.0038***	-0.0038***
			(0.0012)	(0.0012)
Birth Year FE	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	Yes
N	1,725,975	1,725,975	1,725,975	1,725,975
Adjusted R^2	0.078	0.078	0.078	0.078

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for the high bride price (BP) Sub-Saharan Africa (SSA) sample: women aged 25 or older at the time of interview. Observations are at the level of person × age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the grid cell level. All regression specifications include grid cell fixed effects. Results are weighted to be representative of the included countries.

Table 11: Effect of Weather Shocks on Early Fertility in Sub-Saharan-Africa and India

	(1) BP $\geq$ 80%	(2) BP $\geq$ 80%	(3) BP $\geq$ 80%	(4) India DHS	(5) India DHS
Drought	0.0020**	0.0019**	0.0013	0.00090	0.00067
	(0.00087)	(0.00087)	(0.00086)	(0.00086)	(0.00086)
Flood	-0.0017	-0.0017	-0.0017	-0.00085	-0.0011
	(0.0011)	(0.0011)	(0.0010)	(0.00085)	(0.00089)
Birth Year FE	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	No	No
Country FE $\times$ Cohort FE	No	No	Yes	No	No
District FE $\times$ Cohort FE	No	No	No	No	Yes
N	1,743,997	1,743,997	1,743,997	318,576	318,576
Adjusted R^2	0.060	0.060	0.061	0.019	0.020

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for Sub-Saharan Africa (SSA) and India: women aged 25 or older at the time of interview. All columns present results for SSA countries with high prevalence of bride price (BP) custom and for the 1998 India DHS. Observations are at the level of person $\times$ age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the grid cell level. All regression specifications include grid cell fixed effects. Results are weighted to be representative of the included countries. See Table A3 for traditional marriage customs by country.

Table 12: Marriage characteristics by rainfall realization at the time of marriage in Sub-Saharan Africa

	(1) age gap	(2) polygyny	(3) wife rank	(4) no edu	(5) husb no edu	(6) final say	(7) men final say
Drought	-0.18	0.0027	-0.018	0.012**	0.0020	-0.041*	0.059***
	(0.12)	(0.0077)	(0.013)	(0.0053)	(0.0052)	(0.023)	(0.022)
Flood	-0.0080	-0.0067	-0.0098	0.0075	-0.0064	-0.057*	0.074**
	(0.18)	(0.0100)	(0.018)	(0.0071)	(0.0080)	(0.035)	(0.033)
Birth Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Current Age FE	Yes	Yes	Yes	Yes	No	Yes	Yes
Marriage Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	112,836	113,232	45,894	133,732	121,952	120,577	120,577
Adjusted R^2	0.15	0.15	0.050	0.48	0.50	0.26	0.36

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Results for SSA countries with high prevalence of bride price (BP) custom Robust standard errors (in parentheses) are clustered at the grid cell level. All regression specifications include grid cell fixed effects. Results are weighted to be representative of the included countries. See Table A3 for traditional marriage customs by country.

Table 13: Marriage characteristics by rainfall realization at the time of marriage in India

	(1) age gap	(2) no edu	(3) husb no edu
Drought	0.12	0.0026	0.0021
	(0.091)	(0.0065)	(0.0017)
Flood	-0.075	-0.015**	0.0047**
	(0.098)	(0.0067)	(0.0024)
Birth Year FE	Yes	Yes	Yes
Current Age FE	Yes	Yes	Yes
Marriage Year FE	Yes	Yes	Yes
N	33,399	36,426	23,421
Adjusted R^2	0.084	0.16	0.024

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Data form the 1998 India DHS only. Robust standard errors (in parentheses) are clustered at the district level. All regression specifications include district fixed effects.

Table 14: Weather Shocks and Dowry Payments by Child Brides' Families

	(1) Level	(2) Level	(3) Level	(4) Level	(5) Log	(6) Log	(7) Log	(8) Log
Drought	-19621.1	-19680.3	-23128.0*	-22619.6*	-0.16*	-0.17*	-0.21**	-0.20**
	(12772.3)	(13247.4)	(12882.7)	(13311.9)	(0.088)	(0.097)	(0.096)	(0.099)
Flood	8941.9	12531.7	12078.0	13053.2	0.15*	0.16*	0.15*	0.16*
	(9917.8)	(10984.7)	(10680.4)	(10373.9)	(0.090)	(0.096)	(0.084)	(0.082)
Marriage Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bride's age FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Groom's age FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Spouses' education	No	No	Yes	Yes	No	No	Yes	Yes
Parents' education	No	No	No	Yes	No	No	No	Yes
N	1,993	1,951	1,951	1,949	1,790	1,772	1,772	1,770
Adjusted R^2	0.33	0.33	0.35	0.35	0.46	0.46	0.51	0.52

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$, † $p<0.001$
Table shows OLS regressions based on deck 8 of the REDS data. Observations are at the level of a marriage. Robust standard errors (in parentheses) are clustered at the district level. All regression specifications include district fixed effects. Results are weighted to be representative of the included countries.

Table 15: Summary Statistics for Regression Samples: Indonesia

Panel A: Full Sample						
	Obs	Mean	Std. Dev			
Unique Individuals in Sample	7,857					
Percent Married Between Ages 10-17	58,636	4.20	20.06			
Percent Drought	58,636	10.90	31.17			
Percent Flood	58,636	17.61	38.09			
Birth Year	58,636	1965.24	9.45			
Age	58,636	13.34	2.26			
Panel B: Sample according to Ethnographic Atlas						
	Bride price groups			No bride price groups		
	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev
Unique Individuals in Sample	2,112			5,440		
Percent Married Between Ages 10-17	15,863	3.81	19.15	40,461	4.37	0.20
Percent Drought	15,863	8.68	28.16	40,461	11.90	0.32
Percent Flood	15,863	14.79	35.50	40,461	18.68	0.39
Birth Year	15,863	1965.04	9.60	40,461	1965.32	9.44
Age	15,863	13.35	2.26	40,461	13.33	2.25

Note: Table shows summary statistics for the Indonesia regression samples: women aged 25 or older at the time of interview. Observations are at the level of person × age (from 10 to 17 or age of first marriage, whichever is earlier).

Table 16: Effect of Weather Shocks on Early Marriages, by Bride Price Custom in Indonesia

	Full Sample		Sample in EA	BP	No BP
	(1)	(2)	(3)	(4)	(5)
Drought	0.0052*	0.0060**	0.0063**	0.012*	0.0043
	(0.0027)	(0.0027)	(0.0026)	(0.0072)	(0.0027)
Flood	-0.0018	-0.0019	-0.0019	-0.0029	-0.0016
	(0.0015)	(0.0015)	(0.0014)	(0.0028)	(0.0018)
Birth Year FE	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes
N	58,636	58,636	56,324	15,863	40,461
Adjusted R^2	0.043	0.043	0.043	0.044	0.044

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for Indonesia: women aged 25 or older at the time of interview. Observations are at the level of person × age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the province level. All regression specifications include province fixed effects. Columns 2, 3 and 4 include province-by-cohort of birth fixed effects.

A Appendix Tables and Figures

Table A1: List of Data Sets and Sources

Region/ Country	**Data Topic**	**Source**	**Year**
	Marriage	Demographic and Health Survey (DHS)	1994-2012
Sub-Saharan Africa	Crop Yield	FAOStat database	1960-2010
	Conflict	UCDP/PRIO Armed Conflict Dataset	1946-2015
	Marriage	Demographic and Health Survey (DHS)	1998-1999
	Marriage	India Human Development Survey (IHDS)	2005
India	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 (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

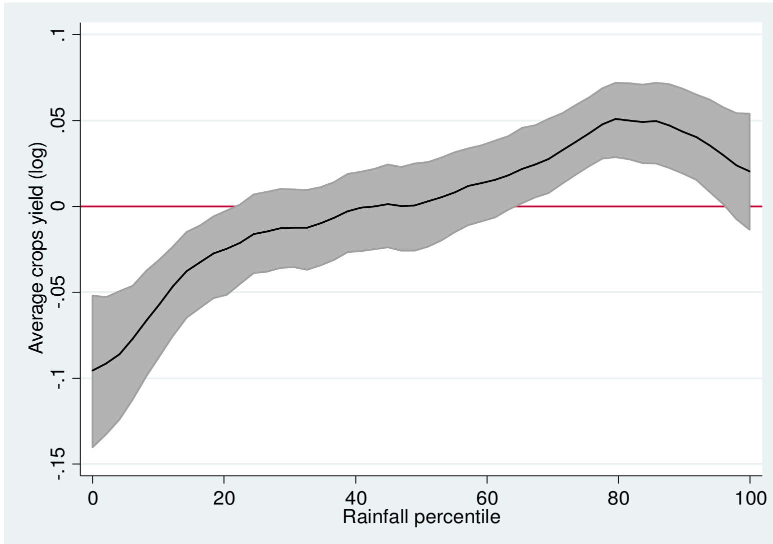
Country	Waves
Benin	1996, 2001, 2011-12
Burkina Faso	1998-99, 2003, 2010
Burundi	2010
Cameroon	2004, 2011
CAR	1994-95, 2013-14
Congo DR	2007
Cote D'Ivoire	1994, 1998-99, 2011-12
Ethiopia	2000, 2005, 2011
Gabon	2012
Ghana	1998, 2003, 2008, 2014
Guinea	1999, 2005, 2012
Kenya	2003, 2008-09, 2014
Lesotho	2004, 2009, 2014
Liberia	2007, 2013
Madagascar	1997, 2008-09
Malawi	2000, 2004, 2010
Mali	1995-96, 2001, 2006, 2012-13
Mozambique	2011
Namibia	2000, 2006-07, 2013
Niger	1998
Nigeria	2003, 2008, 2013
Rwanda	2005, 2010, 2014-15
Senegal	1997, 2005, 2010-11
Sierra Leone	2008, 2013
Swaziland	2006-07
Tanzania	1999, 2010
Togo	1998, 2013-14
Uganda	2000-01, 2006, 2011
Zambia	2007, 2013-14
Zimbabwe	1999, 2005-06, 2010-11

Table A3: Traditional Marriage Customs in Sub-Saharan Africa

Country	% bride price	Country	% bride price
Benin	91%	Malawi	15%
Burkina Faso	83%	Mali	93%
Burundi	99%	Mozambique	44%
Cameroon	93%	Namibia	58%
CAR	65%	Niger	100%
Congo DR	84%	Nigeria	91%
Cote d'Ivoire	69%	Rwanda	100%
Ethiopia	66%	Senegal	98%
Gabon	74%	Sierra Leone	99%
Ghana	94%	Swaziland	97%
Guinea	94%	Tanzania	81%
Kenya	100%	Togo	62%
Lesotho	100%	Uganda	97%
Liberia	98%	Zambia	19%
Madagascar	13%	Zimbabwe	87%

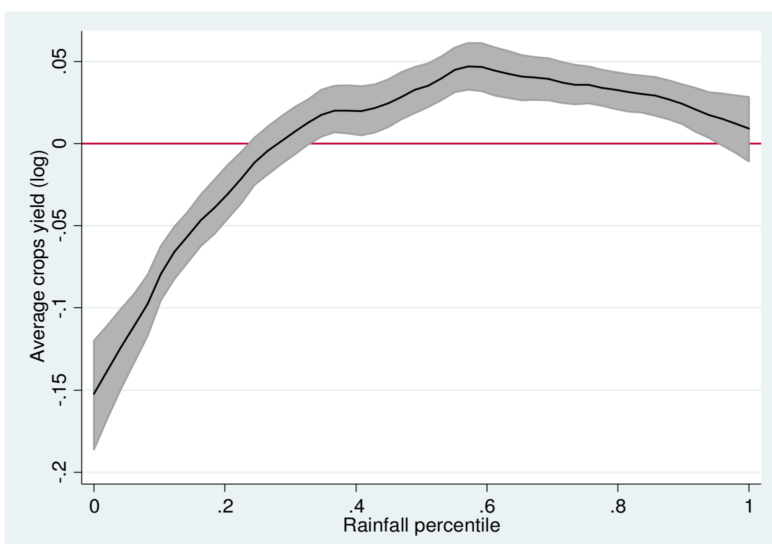
Note: Data from Ethnomaps (available at http://www.ethnomaps.ch/hpm-e/atlas-e.html, accessed February 7, 2016).

Figure A1: Weather Shocks and Cereal Yields in Sub-Saharan Africa:
Local Linear Regression



Note: 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 gray.

Figure A2: Weather Shocks and Crop Yields in India:
Local Linear Regression



Note: 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 gray.

Table A4: Effects of Drought by Age

	(1) SSA, BP $\geq$ 80%	(2) India
Drought at Age 10	-0.0094†	0.0054*
	(0.0021)	(0.0033)
Drought at Age 11	-0.0092†	0.0036
	(0.0020)	(0.0033)
Drought at Age 12	-0.0031	0.00061
	(0.0024)	(0.0028)
Drought at Age 13	0.0077***	0.00062
	(0.0030)	(0.0037)
Drought at Age 14	0.0085**	-0.0084*
	(0.0035)	(0.0051)
Drought at Age 15	0.019†	-0.0077
	(0.0041)	(0.0058)
Drought at Age 16	0.0042	-0.031†
	(0.0041)	(0.0080)
Drought at Age 17	0.017***	-0.011
	(0.0051)	(0.0087)
Birth Year FE	Yes	Yes
Age FE	Yes	Yes
Country FE	Yes	No
N	1,727,772	540,130
Adjusted R^2	0.078	0.094

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions with heterogeneous effects of drought by age for the high bride price (BP) Sub-Saharan Africa (SSA) and full India regression samples: women aged 25 or older at the time of interview. Observations are at the level of person × age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the grid cell level (SSA) or district level (India). All regression specifications include grid cell (SSA) or district (India) fixed effects. Results are weighted to be representative of the included countries (SSA) or districts (India). These coefficients and the 95% confidence intervals are plotted in Figure 3.

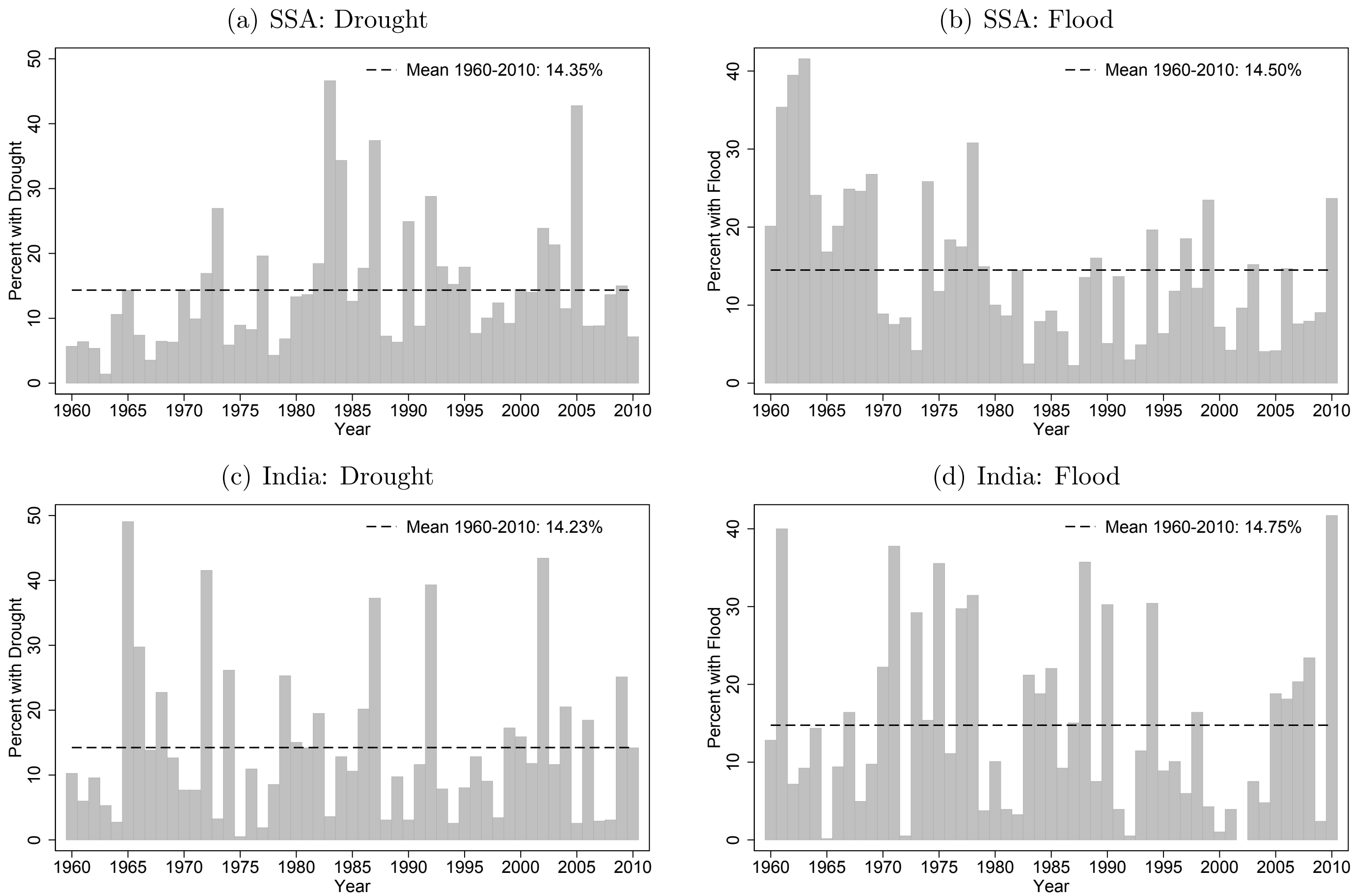
Table A5: Effect of Rainfall Shocks by Quintile

	(1) SSA, BP $\geq$ 80%	(2) India
Bottom Quintile	0.0018*	-0.0035*
	(0.0010)	(0.0018)
Top Quintile	-0.0025**	0.00081
	(0.0012)	(0.0021)
Birth Year FE	Yes	Yes
Age FE	Yes	Yes
Country FE	Yes	No
N	1,727,772	540,130
Adjusted R^2	0.078	0.094

Note: * p<0.1, ** p<0.05, *** p<0.01, † p<0.001
Table shows OLS regressions for the high bride price (BP) Sub-Saharan Africa (SSA) and full India regression samples: women aged 25 or older at the time of interview. Observations are at the level of person $\times$ age (from 10 to 17 or age of first marriage, whichever is earlier). Robust standard errors (in parentheses) are clustered at the grid cell level (SSA) or district level (India). All regression specifications include grid cell (SSA) or district (India) fixed effects. Results are weighted to be representative of the included countries (SSA) or districts (India).

B Orthogonality of Weather Shocks

Figure B1: Prevalence of Weather Shocks in Sub-Saharan Africa and India by Year



Note: Figures shows the prevalence of drought and flood in Sub-Saharan Africa (SSA) and India, presented as the percentage of grid cells (SSA) or districts (India) with these weather shocks in each year. The weather shocks are defined based on calendar years. For all the analyses in this paper, for any grid cell or district, we define a drought as having rainfall lower than the 15^{th} percentile of the long-run rainfall distribution, and a flood as having rainfall greater than the 85^{th} percentile of the same distribution. The black dashed line shows the mean of drought/flood in each sub-figure from 1960-2010.

C Theoretical appendix

C.1 Proofs

Proof of proposition 1 The derivatives of equilibrium quantities in the two economies with respect to income are equal to

$$\frac{\partial Q(y_1)^{SSA}}{\partial y_1} = \frac{2 - H^f - H^m}{H^f - H^m} \qquad \frac{\partial Q(y_1)^{IND}}{\partial y_1} = \frac{2 - H^f - H^m}{H^m - H^f}.$$

In both economies, the sign of the derivative is equal to the sign of the term $2 - H^f - H^m$. This means that, when τ_2^* (sub-Saharan Africa) we can expect low income to lead to more marriages whenever $2 - H^f - H^m < 0$ or $\frac{1}{H^f - 1} < -\frac{1}{H^m - 1}$. In this case, H_m is increasing in w^m: when w^m is larger, the inequality is more likely to be satisfied. When τ_2^* (India), we can expect low income to lead to fewer marriages whenever $2 - H^f - H^m > 0$, or that $-\frac{1}{H^f - 1} < \frac{1}{H^m - 1}$. In this case, H_m is decreasing in w^m: again, when w^m is larger, the inequality is more likely to be satisfied.

Proof of proposition 2 The derivative with respect to income is

$$\frac{\partial \tau_1^*(y_1)}{\partial y_1} = 2\frac{(1 - H^f)(1 - H^f)}{H^f - H^m}.$$

This derivative is positive when transfers are positive (i.e. bride price payments are higher when income is higher), as they imply that $H^f > 1$ and $H^m < 1$. It is negative, instead, when transfers are negative (i.e. dowry payments, which are $-\tau_1^*$, are also higher when income is higher), as they imply that $H^f < 1$ and $H^m > 1$.

C.2 Generalization of the model

Consider general preferences represented by a function $u(\cdot)$ which is strictly increasing, strictly concave and twice-continuously differentiable. Allow also the distribution of ϵ_t to follow a continuous distribution with pdf $f(\cdot)$ and cdf $F(\cdot)$ for both men and women.

As in the log-utility case, a woman from household i will get married in the first period if and only if:

$$u(y_1 + \epsilon_1^i + \tau_1) + \xi^f + E\left[u(y_2 + \epsilon_2^i)\right] \geq u(y_1 + \epsilon_1^i) + E\left[u(y_2 + \epsilon_2^i + \tau_2^*)\right]$$

Similarly, a man from household j will get married in the first period if and only if:

$$\begin{aligned} &u(y_1 + \epsilon_1^j - \tau_1) + \xi^m + E\left[u(y_2 + \epsilon_2^j + w^m + w^f)\right] \geq \\ &u(y_1 + \epsilon_1^j) + E\left[u(y_2 + \epsilon_2^j + w^m + w^f - \tau_2^*)\right]. \end{aligned}$$

Consider now the income thresholds ϵ_f^* and ϵ_m^* at which the above expressions hold with equality:

$$\begin{aligned} &u(y_1 + \epsilon_1^{f*} + \tau_1) + \xi^f - u(y_1 + \epsilon_1^{f*}) = \Omega^f \\ &u(y_1 + \epsilon^{m*} - \tau_1) + \xi^m - u(y_1 + \epsilon^{m*}) = \Omega^m. \end{aligned}$$

Define $\Omega^f = E\left[u(y_2 + \epsilon_2^i + \tau_2^*)\right] - E\left[u(y_2 + \epsilon_2^i)\right]$ and $\Omega^m = E\left[u(y_2 + \epsilon_2^j + w^m + w^f - \tau_2^*)\right] - E\left[u(y_2 + \epsilon_2^j + w^m + w^f)\right]$. Applying the implicit function theorem (IFT), we have that

$$\begin{aligned}
\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1} &= -\frac{u'(y_1 + \epsilon_f^* + \tau_1)}{u'(y_1 + \epsilon_f^* + \tau_1) - u'(y_1 + \epsilon_f^*)} \\
\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial y_1} &= -\frac{u'(y_1 + \epsilon_f^* + \tau_1) - u'(y_1 + \epsilon_f^*)}{u'(y_1 + \epsilon_f^* + \tau_1) - u'(y_1 + \epsilon_f^*)} = -1 \\
\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1} &= \frac{u'(y_1 + \epsilon_m^* - \tau_1)}{u'(y_1 + \epsilon_m^* - \tau_1) - u'(y_1 + \epsilon_m^*)} \\
\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial y_1} &= -\frac{u'(y_1 + \epsilon_m^* - \tau_1) - u'(y_1 + \epsilon_m^*)}{u'(y_1 + \epsilon_m^* - \tau_1) - u'(y_1 + \epsilon_m^*)} = -1.
\end{aligned}$$

Sub-Saharan Africa Monotonicity and concavity of the utility function, as well as the fact that continuation values do not depend on ϵ_1^i, imply that below threshold ϵ_f^* every household wants their daughter to be married, *ceteris paribus*. This implies that the supply of brides is defined in SSA as:

$$S^{SSA}(\tau_1, y_1, \Omega^f) = Prob(\epsilon_i < \epsilon_f^*(\tau_1, y_1, \Omega^f)) = F(\epsilon_f^*(\tau_1, y_1, \Omega^f)).$$

Concavity ensures that $\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1} > 0$.

The above conditions, together with the chain rule and the fact that $F'(\cdot) = f(\cdot) > 0$, also imply that

$$\frac{\partial S^{SSA}(\tau_1, y_1, \Omega^f)}{\partial \tau_1} = S_\tau^{SSA}(\tau_1, y_1, \Omega^f) = f(\epsilon_f^*(\tau_1, y_1, \Omega^f))\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1} > 0$$

$$\frac{\partial S^{SSA}(\tau_1, y_1, \Omega^f)}{\partial y_1} = S_y^{SSA}(\tau_1, y_1, \Omega^f) = -f(\epsilon_f^*(\tau_1, y_1, \Omega^f)) < 0.$$

A similar argument would lead us to show that the demand for brides is

$$D^{SSA}(\tau_1, y_1, \Omega^f) = Prob(\epsilon_i \geq \epsilon_m^*(\tau_1, y_1, \Omega^m)) = 1 - F(\epsilon_m^*(\tau_1, y_1, \Omega^m))$$

and the derivative of the threshold with respect to the marriage payment is $\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1} > 0$. Hence, because of continuity and the chain rule

$$\begin{aligned}
\frac{\partial D^{SSA}(\tau_1, y_1, \Omega^f)}{\partial \tau_1} &= D_\tau^{SSA}(\tau_1, y_1, \Omega^m) = -f(\epsilon_m^*(\tau_1, y_1, \Omega^m))\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1} < 0 \\
\frac{\partial D^{SSA}(\tau_1, y_1, \Omega^f)}{\partial y_1} &= D_y^{SSA}(\tau_1, y_1, \Omega^m) = f(\epsilon_m^*(\tau_1, y_1, \Omega^m)) > 0.
\end{aligned}$$

India The same arguments used above, when transfers are negative, would lead us to conclude that $\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1} < 0$ and $\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1} < 0$. Hence

$$\begin{aligned}
S^{IND}(\tau_1, y_1, \Omega^f) &= Prob(\epsilon_i \geq \epsilon_f^*(\tau_1, y_1, \Omega^f)) = 1 - F(\epsilon_f^*(\tau_1, y_1, \Omega^f)) \\
D^{IND}(\tau_1, y_1, \Omega^m) &= Prob(\epsilon_i < \epsilon_m^*(\tau_1, y_1, \Omega^m)) = F(\epsilon_m^*(\tau_1, y_1, \Omega^m)).
\end{aligned}$$

The derivatives are the following:

$$\frac{\partial S^{IND}(\tau_1, y_1, \Omega^f)}{\partial \tau_1} = S_\tau^{IND}(\tau_1, y_1, \Omega^f) = -f(\epsilon_f^*(\tau_1, y_1, \Omega^f))\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1} > 0$$
$$\frac{\partial S^{IND}(\tau_1, y_1, \Omega^f)}{\partial y_1} = S_y^{IND}(\tau_1, y_1, \Omega^f) = f(\epsilon_f^*(\tau_1, y_1, \Omega^f)) > 0$$
$$\frac{\partial D^{IND}(\tau_1, y_1, \Omega^m)}{\partial \tau_1} = D_\tau^{IND}(\tau_1, y_1, \Omega^m) = f(\epsilon_m^*(\tau_1, y_1, \Omega^m))\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1} < 0$$
$$\frac{\partial D^{IND}(\tau_1, y_1, \Omega^m)}{\partial y_1} = D_y^{IND}(\tau_1, y_1, \Omega^m) = -f(\epsilon_m^*(\tau_1, y_1, \Omega^m)) < 0.$$

Equilibrium In both economies, equilibrium prices are defined implicitly as the solution to

$$S(\tau_1^*, y_1, \Omega^f) - D(\tau_1^*, y_1, \Omega^m) = 0.$$

By the IFT, the derivative of the equilibrium price with respect to y_1 is

$$\frac{\partial \tau_1^*}{\partial y_1} = -\frac{S_y(\tau_1, y_1, \Omega^f) - D_y(\tau_1, y_1, \Omega^m)}{S_\tau(\tau_1, y_1, \Omega^f) - D_\tau(\tau_1, y_1, \Omega^m)}.$$

This derivative is negative in SSA and positive in India (as stated in proposition 2).

Define now $\tau = S^{-1}(q_1, y_1, \Omega^f)$ as an inverse supply function and $\tau = D^{-1}(q_1, y_1, \Omega^m)$ as an inverse demand function. Note that $S_q^{-1}(q, y_1, \Omega^f)$ and $D_q^{-1}(q, y_1, \Omega^m)$ have the same sign as $S_\tau(\tau_1, y_1, \Omega^f)$ (positive) and $D_\tau(\tau_1, y_1, \Omega^m)$ (negative), respectively. Moreover, $S_y^{-1}(q, y_1, \Omega^f) = -\frac{S_y(\tau_1, y_1, \Omega^f)}{S_\tau(\tau_1, y_1, \Omega^f)}$ is positive SSA and negative in India, as is $D_y^{-1}(q, y_1, \Omega^m) = -\frac{D_y(\tau_1, y_1, \Omega^m)}{D_\tau(\tau_1, y_1, \Omega^m)}$.

In equilibrium, $D^{-1}(q_1^*, y_1, \Omega^m) = \tau^* = S^{-1}(q_1^*, y_1, \Omega^f)$ where q^* is the equilibrium quantity of child marriage. Again the IFT allows us to derive

$$\frac{\partial q_1^*}{\partial y_1} = -\frac{S_y^{-1}(q_1^*, y_1, \Omega^f) - D_y^{-1}(q_1^*, y_1, \Omega^m)}{S_q^{-1}(q_1^*, y_1, \Omega^f) - D_q^{-1}(q_1^*, y_1, \Omega^m)}.$$

The denominator of the above expression, $S_q^{-1,SSA}(q_1^*, y_1, \Omega^f) - D_q^{-1,SSA}(q_1^*, y_1, w^m, \Omega^m)$, is always positive.

Hence, in SSA, in order to have that $\frac{\partial q_1^*}{\partial y_1} > 0$, we need that $S_y^{-1,SSA}(q_1^*, y_1, \Omega^f) < D_y^{-1,SSA}(q_1^*, y_1, \Omega^m)$, hence that $-\frac{S_y^{SSA}(\tau_1, y_1, \Omega^f)}{S_\tau^{SSA}(\tau_1, y_1, \Omega^f)} < -\frac{D_y^{SSA}(\tau_1, y_1, \Omega^m)}{D_\tau^{SSA}(\tau_1, y_1, \Omega^m)}$ or

$$\frac{S_y^{SSA}(\tau_1, y_1, \Omega^f)}{S_\tau^{SSA}(\tau_1, y_1, \Omega^f)} > \frac{D_y^{SSA}(\tau_1, y_1, \Omega^m)}{D_\tau^{SSA}(\tau_1, y_1, \Omega^m)}.$$

Applying the above derivations of these partial derivatives, we have that:

$$\frac{S_y^{SSA}(\tau_1, y_1, \Omega^f)}{S_\tau^{SSA}(\tau_1, y_1, \Omega^f)} = -\frac{1}{\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1}}$$

and

$$\frac{D_y^{SSA}(\tau_1, y_1, \Omega^m)}{D_\tau^{SSA}(\tau_1, y_1, \Omega^m)} = \frac{f(\epsilon_m^*(\tau_1, y_1, \Omega^m))}{-f(\epsilon_m^*(\tau_1, y_1, \Omega^m))\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1}} = -\frac{1}{\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1}}.$$

Hence, the condition translates into

$$\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1} < \frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1},$$

In India, in order to have that $\frac{\partial q_1^*}{\partial y_1} < 0$, we need that $S_y^{-1,IND}(q_1^*, y_1) > D_y^{-1,IND}(q_1^*, y_1)$, hence that $-\frac{S_y^{IND}(\tau_1, y_1, \Omega^f)}{S_\tau^{IND}(\tau_1, y_1, \Omega^f)} > -\frac{D_y^{IND}(\tau_1, y_1, \Omega^m)}{D_\tau^{IND}(\tau_1, y_1, \Omega^m)}$ or

$$\frac{S_y^{IND}(\tau_1, y_1, \Omega^f)}{S_\tau^{IND}(\tau_1, y_1, \Omega^f)} < \frac{D_y^{IND}(\tau_1, y_1, \Omega^m)}{D_\tau^{IND}(\tau_1, y_1, \Omega^m)}.$$

Applying the above derivations of these partial derivatives, we have that:

$$\frac{S_y^{IND}(\tau_1, y_1, \Omega^f)}{S_\tau^{IND}(\tau_1, y_1, \Omega^f)} = -\frac{1}{\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1}}$$

and

$$\frac{D_y^{IND}(\tau_1, y_1, \Omega^m)}{D_\tau^{IND}(\tau_1, y_1, \Omega^m)} = \frac{-f(\epsilon_m^*(\tau_1, y_1, \Omega^m))}{f(\epsilon_m^*(\tau_1, y_1, \Omega^m))\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1}} = -\frac{1}{\frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1}}.$$

Hence, the condition translates into

$$\frac{\partial \epsilon_f^*(\tau_1, y_1, \Omega^f)}{\partial \tau_1} > \frac{\partial \epsilon_m^*(\tau_1, y_1, \Omega^m)}{\partial \tau_1},$$

As in the less general case, both these conditions become more likely to hold then w^m (and w^f, holding τ_2^* constant) become larger (proposition 1).