Selling daughters: Child Marriage, Income Shocks and the Bride Price Tradition

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Abstract

This paper investigates the relationship between child marriage and income shocks in a setting where the bride price - transfer from the groom to the bride's parents at marriage - is customary. First, we develop a dynamic model in which households are exposed to income volatility and have no access to credit markets. If a daughter marries, her household obtains a bride price. In this framework, girls may have a higher probability of marrying early when their parents have higher marginal utility of consumption because of adverse income shocks. Second, we test the responsiveness of child marriage to income fluctuations by exploiting idiosyncratic variation in rainfall over a woman's life cycle, using a survey dataset from rural Tanzania. We find that adverse shocks during teenage years increase the probability of early marriages. Third, we use these empirical results to estimate the parameters of our model and isolate the role of the bride price custom for consumption smoothing. In counterfactual exercises, we show that child marriage bans can have lasting effects on age of marriage even after they are no longer binding and they do so at a limited utility cost to households. Cash transfers, both conditional on avoiding child marriage and unconditional, can reduce early marriages, especially when they target low-income households.

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1 Introduction

Child marriage is still a common practice in many countries, especially among girls. Worldwide, 700 million women alive today married before turning 18. This phenomenon is especially pronounced in Sub-Saharan Africa and South Asia, where the prevalence is 56% and 42%, respectively (UNICEF, 2019).[1] The relationship between female early marriage and poor physical and socioeconomic outcomes is well established in the literature. Child marriage is associated with lower educational attainment, lower use of preventive health care services, lower bargaining power within the household, physical abuse and domestic violence (Jensen and Thornton, 2003; Field and Ambrus, 2008; Chari et al., 2017).[2] Despite this evidence, little research has examined the important question of why such a practice is still so widespread in many countries and what might be effective policies to reduce it.

This paper has two main goals. First, we estimate the responsiveness of child marriage to income fluctuations in a setting where the bride price, a transfer from the groom to the family of the bride at the time of marriage, is customary, in order to understand the mechanisms by which child marriage and income shocks are related. Second, we use these estimates to perform counterfactual simulations to evaluate effective economic policies potentially able reduce the practice.

To address the first goal, we start by theoretically exploring the relationship between the probability of child marriage – defined as a formal or informal union in which at least one member gets married before the age of 18 (UNICEF, 2014) – and adverse income shocks in a setting with bride price. We develop a dynamic model in which households face income variability and have no access to credit markets. A daughter may be costly to support, or can contribute to her household's budget through her labor supply or home production. Upon the marriage of a daughter, parents obtain a bride price payment, which depends on her age. In this framework, a negative income shock is associated with an increase in the probability of marriage in the same period, as long as

[1]Niger (76%), Central African Republic (68%) and Chad (67%) are among the countries with the highest prevalence (UNICEF, 2019).

[2]Based on these findings, international organizations have called for "urgent action", arguing that the eradication of child marriage is a necessary step towards improving female human capital accumulation, empowerment and autonomy around the world (UNFPA, 2012; UNICEF, 2014). The elimination of harmful practices is also part of the Sustainable Development Goals 2015-2030, a collection of 17 global goals set by the United Nations General Assembly reflecting the priorities to reduce poverty around the world.

the bride price exceeds the daughter's contribution to home production.

We test this theoretical prediction using a survey dataset from a region in Tanzania, the Kagera Health Development Survey 1991-2010 (KHDS), which elicited detailed information on bride price payments, and weather data from the NASA Langley Research Center. In particular, we exploit exogenous variation in rainfall to estimate the causal effects of rainfall shocks on the age of marriage. Negative rainfall shocks, measured as the absolute deviation of rainfall from the historical mean at the village level, are associated with sizable declines in household consumption. To examine the relationship between rainfall shocks and the timing of marriage, we match each woman to the community in which she grew up, and reconstruct the patterns of rainfall shocks that she experienced over time. Because marriage migration is prevalent among brides in these communities, we consider these rainfall deviations as idiosyncratic shocks to the village resources relative to the overall marriage market, which encompasses the Kagera region. Hence, we control for year-of-birth fixed effects to account for variation at the level of the marriage market, and for village fixed effects to account for the cross-sectional variation in the timing of marriage across the communities of origin of each woman.

We find that girls whose families were hit by a negative rainfall shock in their teenage years have a higher probability of being married by the age of 18. As expected, shocks that occur after that age do not have any statistically significant effect on the likelihood of early marriage. On the contrary, rainfall shocks are not associated with early marriages for boys, but, in line with the fact that men marry later than women on average in the data, we find weak evidence that rainfall shocks in their own communities delay marriage to later ages. By exploiting data on bride price amount, we also show that the relationship between female child marriage and negative income shocks is stronger in villages where bride price payments are typically higher. In line with the idiosyncratic nature of the rainfall shocks, we do not find that these shocks affect the level of bride price paid at the time of marriage.

To disentangle the role of bride price as a consumption-smoothing mechanism, we estimate the parameters of our dynamic model by indirect inference, targeting the responsiveness of child marriage to resource shocks, the marriage-age profile, and the empirical distribution of consumption.

We find that families generally prefer to delay the marriage of their daughters, but that the inability to borrow or save leads to an age of marriage that is often lower than what optimal from the household's preferences. In this model, a bride price is also crucial for marriage to occur, because daughters are productive in their parents' home. In counterfactual exercises, we find that child marriage bans can have lasting effects on the age of marriage even after they are no longer binding, because marriage rate do not immediately increase once the girls is eligible to marry. Nevertheless, because child marriage is a tool to cope with income volatility, a marriage ban comes with a utility cost, albeit a small one. Other policies, such as unconditional or conditional cash transfers, can be effective at reducing child marriage, especially when they target low-income households.

Our paper fits into four main strands of the literature. First, the paper is related to the recent literature looking at the effect of income shock on marriage decisions. Hoogeveen, Van der Klaauw and Van Lomwel (2011) investigate the effect of economic conditions on marriage's choices among a small sample of Zimbabwean smallholder farmers in rural areas. They find that the marriage rate for daughters is higher when households experience changes in their livestock, but not when aggregate rainfall is low. Relative to this paper, we focus on the effect of exogenous income shocks and we have the advantage of exploiting a larger sample that allows us to identify the elasticity of child marriage to income shocks, which informs then our structural estimates. Corno, Hildebrandt and Voena (2020) study the impact of *aggregate* rainfall shocks on child marriage in Sub-Saharan Africa and India and show an opposite effect of the shocks on the early marriage hazard in the two regions: in Africa, they increase the hazard into early marriage, while in India, they decrease it. This differential response is explained by differences in the direction of traditional marriage payments in each region, with bride price being prevalent in Africa and dowry in India. Compared to this study we rely on one of the very few surveys that elicits information on bride price amount. Exploiting the bride price data, we can estimate a dynamic discrete choice model of age of marriage, and use it to conduct counterfactual simulations of different policies aimed at reducing child marriage. Furthermore, we examine idiosyncratic shocks instead of aggregate shocks.

Second, it contributes to the large economic literature that investigates the coping mechanisms used by poor households to deal with income risk. Despite imperfect markets for formal insurance, rural households seem well-equipped to smooth consumption to face short-term, idiosyncratic income shocks, often through informal insurance arrangements, such as transfers in family networks, storage of crops, diversification of farmers' landholdings (Rosenzweig, 1988; Rosenzweig and Stark, 1989; Townsend, 1994; Fafchamps and Lund, 2003; De Weerdt and Dercon, 2006; Angelucci, De Giorgi and Rasul, 2018). In this paper, using detailed data on bride price payment, we confirm a recent hypothesis that in societies where bride price is customary, child marriage can be another strategy to smooth consumption thus perpetuating the risk of poverty (Corno, Hildebrandt and Voena, 2020).

Third, it is related to the broad literature in economics investigating the role of cultural and social norms on economic behavior. Much of this work has studied the role of cultural values and beliefs such as trust, family ties, and gender norms on economic outcomes (Platteau, 2000; Fernandez, Fogli and Olivetti, 2004; Guiso, Sapienza and Zingales, 2006; Fernandez and Fogli, 2009; Tabellini, 2010; Nunn and Wantchekon, 2011; Corno, La Ferrara and Voena, 2020). A growing part of this literature has explored the influence of marriage practices (e.g., polygyny, patrilocal norms, dowry and bride price) on development (see, among others, Jacoby (1995); Tertilt (2005); Anderson and Bidner (2015); Corno, Hildebrandt and Voena (2020); Ashraf et al. (2020)). The latter remains a particularly worthwhile yet under-explored topic to study, given that marriage practices are likely to have a profound effect on people's life and on their economic circumstances (Botticini, 1999). Compared to these previous works, we examine the role of the bride price payment on child marriage through the lenses of a structural model that allows for policy experiments.

Finally, the paper is also related to the literature showing that children's outcomes, and particularly girls' outcomes, in developing countries are sensitive to income fluctuations (Foster, 1995). Björkman-Nyqvist (2013) find that a negative income shock has an adverse effect on the test scores of female students. The results imply that households respond to income shocks by varying the amount of schooling and resources provided to daughters.

The remainder of the paper is organized as follows. In section 2, we describe the tradition of marriage payments, in section 3 we develop a theoretical framework to highlight the relationship between income shocks, bride price payments and the timing of marriage. Section 4 presents the data and descriptive statistics. In section 5, we describe the empirical strategy, in section 6 we report our main results and robustness checks. Section 7 shows the counterfactual policy simulations of the model under different assumptions about the credit markets and section 8 concludes.

2 Child marriages and bride price payment

Transfers of resources between spouses and their families are a crucial element in the marriage culture of many developing countries. Bride prices and dowries are the most well-known types of marriage payments. Bride price payment is a cash or in-kind transfer given by or on behalf of the groom to the family of the bride upon the marriage. On the contrary, dowry payments involve a transfer from the bride to the family of the groom upon the marriage.[3]

Historically, the custom of bride price has been more common than that of dowry. Less than 4 percent of the ethnic groups listed in the George Peter Murdock's (1967) *Ethnographic Atlas* have dowry payments, whereas about two-thirds follow a norm of bride price payment.[4] However, dowry payments have been studied more extensively in the economics literature, possibly because they mainly occurred in Europe and Asia, where more than 70 percent of the world's population resides. Although the custom of dowry has disappeared in most of the western regions, it remains widespread in South Asia. Bride price payments have as well an ancient tradition and are common across sub-Saharan Africa. In the southern regions it is known as *lobola* and in East Africa as *mahari*. Beside Africa, bride price custom is widespread in some regions of South and East Asia, such as Indonesia (Maitra, 2007).

Depending on cultural traditions, the bride price can be paid either in cash, in-kind or a combination of both. In both cases they usually represent large transfers of money across households at the time of marriage and as such we believe they have important consequences on households'

[3]For studies investigating the historical occurrence of bride price versus dowry see Boserup (1970); Grossbard (1978); Becker (1981); Giuliano (2014); Goody and Tambiah (1973); Botticini and Siow (2003); Maitra (2007).

[4]The Atlas provides historical information on transfers made at marriage, either bride price or dowry, by ethnic groups all over the world (Murdock, 1967).

economic decisions.

The debate over the adverse consequences of the bride price custom is currently lively in Africa (see, among others, Makoye 2013 and Mtui 2013). It has been argued that this practice increases the incentive for parents to "sell off" their daughters to a groom in order to receive a bride price and has contributed to child marriages, so encouraging forced and early marriages. Girls are removed from school to be married off as young as possible so the families can get in cash or in kind payment. Unfortunately, to the best of our knowledge, cross-country data on bride price amount are not available but anecdotal evidence suggests that the younger the bride is, the higher is the bride price paid, because youth ensures chastity. In a recent interview of the Thompson Reuters Foundation conducted in a village in Bagamoyo, Tanzania, a 15-year-old bride says "*I was very shocked because I was too young and I didn't want to get married since I was still at school. But I couldn't go against my father's wishes who wanted to get a payment to cover his financial problem*" and "*My dream was to become a teacher, but I could not fulfill it as I got married and became pregnant. Now I have a child and it's unlikely I will go back to school*" (Makoye, 2013). Furthermore, bride price custom also affects a women's right to divorce because men can demand to the bride's parents the return of the payment: a high bride-price serves as a commitment device aimed at minimizing the risk of marriage breakup (The Guardian, 2015).

3 The model

In this section, we develop a dynamic discrete-choice model with incomplete markets in which households are exposed to idiosyncratic shocks to their income and cannot borrow or save. We later estimate the parameters of this structural model and use it to quantify the role of bride price and child marriages in providing consumption insurance to households that lack access to credit markets.

Decisions are made by parents, who have one daughter and obtain a bride price payment BP_a upon her marriage. The bride price BP_a is a function of the daughter's age. Income y_a is an i.i.d. stochastic process. Households live till time T and will marry their daughter by age A, with $14 < A < T$.[5] Period 1 is the time of birth of the daughter, and hence we can refer to periods

[5] We set the initial period to age 14, when considerations on child marriage are less relevant. For an analysis of

and a woman's ages interchangeably. Parents maximize discounted expected utility over their consumption and have a per-period utility function $u(c)$ which has constant relative risk aversion coefficient b (hence, $u(c) = \frac{c^{1-b}}{1-b}$). In each period, a state of nature s_a is realized, which corresponds to a realization of the i.i.d. income process $y_a(s_a)$. Denote $s^a = \{s_{14}, ...s_a\}$ the history of states of nature between age 14 and age a. Parents observe $y_a(s_a)$ and choose consumption $c_a(s^a)$. If their daughter is unmarried (denoted as $M_{a-1}(s^{a-1}) = 0$), they choose whether or not to give her in marriage at that age $m_a(s^a) \in \{0, 1\}$. If the daughter marries, $m_a(s^a) = 1$, this results in $M_a(s^a) = 1$.

The parents solve the following problem:

$$
\begin{aligned}
max_{c \geq 0, m \in \{0,1\}} \qquad & \sum_{a=14}^{T} \delta^{a-14} E\left[u\left(c_a(s^a)\right)\right] + m_a(s^a) \cdot \xi_a \\
s.t. \quad & \frac{c_a(s^a)}{1 + e \cdot (1 - M_a(s^a))} \leq y_a(s_a) + BP_a \cdot m_a(s^a) \\
& M_{13} = 0.
\end{aligned}
$$

For every period t and state of nature s^a :

$$
\begin{aligned}
& \text{if } M_{a-1}(s^{a-1}) = 1, \text{ then } m_a(s^a) = 0 \\
& \text{if } M_{a-1}(s^{a-1}) = 0 \text{ and } m_a(s^a) = 0, \text{ then } M_a(s^a) = 0 \\
& \text{if } m_a(s^a) = 1, \text{ then } M_a(s^a) = 1, ..., M_A(s^A) = 1.
\end{aligned}
$$

The parameter e captures the proportional contribution provided or the cost imposed by a daughter on the household consumption when she is living with her parents: a negative e implies that the daughter is costly to support, while a positive e captures any contribution of the daughter to consumption through home production. Last, the age specific-parameter ξ_a represents the utility gain or cost of having the daughter marry at age a.

In this simple framework, the daughter acts as an indivisible asset and the timing of her marriage is an optimal stopping problem. The demand for brides by potential husbands is unaffected by $y_a(s_a)$, which is idiosyncratic to the bride's family. The daughter can get married in any period as

child labor in the KHDS data, see Beegle, Dehejia and Gatti (2006).

long as the parents choose so.

We examine the relationship between the realization of income in a given period ($y_a(s_a)$) and the marriage probability over the life cycle. When there is a negative income shock, the parents' marginal utility of consumption is higher, and the value of marrying the daughter and immediately obtaining the bride price payment, rather than waiting, is greater as long as $e \cdot y$ is smaller than the bride price.

As long as the bride price exceeds the value of the services provided by a daughter, a low realization of income in period a increases the probability that the daughter marries in a period. Hence, for any period $a = \{14, 15, 16, 17, 18\}$, a negative income realization increases the probability of child marriage, defined as $P(M_{18} = 1) = 1 - \prod_{\alpha=14}^{18} P(m_\alpha = 0)$, i.e. one minus the probability that the girl never marries between the ages of 14 and 18.

To obtain this prediction, consider that the parents' problem admits the following recursive formulation:

$$
\begin{aligned}
V_a^{M_{a-1}}(s^a) = max_{c_a \geq 0, m_a \in \{0,1\}} \qquad & u(c_a) + \xi_a \cdot m_a(s^a) + \delta E[V_{a+1}^{M_a}(s^{a+1})|s^a] \\
s.t. \quad \frac{c_a(s^a)}{1 + e \cdot (1 - M_a(s^a))} & \leq y_a(s_a) + BP_a \cdot m_a(s^a).
\end{aligned}
$$

The problem can be solved backwards (Adda and Cooper, 2003). In every period between $A+1$ and T, parents just consume their stochastic income. At the last marriageable age A, we have imposed that for every realization of the state of nature, if the daughter is not yet married, she will marry. If the daughter is married, the parents will consume their stochastic income. In every other period $a \in [14, A-1]$, the value of marrying is equal to:

$$V_a^0(m_a = 1) = u(y_a + BP_a) + \xi_a + \delta E[V_{a+1}^1]$$

and the value of waiting to marry at age a is equal to:

$$V_a^0(m_a = 0) = u(y_a \cdot (1 + e)) + \delta E[V_{a+1}^0]$$

where we omit the s^a for simplicity. Hence, when $M_a = 0$, parents decide to marry off their daughter, $m_a = 1$, if and only if the value of marriage exceeds the value of waiting:

$$u(y_a + BP_a) + \delta E[V^1_{a+1}] > u(y_a \cdot (1 + e)) + \delta E[V^0_{a+1}].$$

A drop in income y_a increases the probability of marriage at age a when $e < BP_a$. This is because, in the absence of credit markets, the continuation values $V_{a+1}(\ )$ do not depend on y_a and the strict concavity of the utility function ensures that $\frac{\partial[u(y_a+BP_a)-u(y_a\cdot(1+e))]}{\partial y_a} < 0$.

In what follows, we will test this prediction using rainfall shocks as an exogenous source of variation in income. We will then structurally estimate the above model to establish the quantitative importance of credit market imperfections in determining age of marriage when bride price payments are customary.

This setup relies on the assumption that we can identify idiosyncratic shocks to households that do not affect the overall marriage market. One limitation of using rainfall realizations is that other households in the same marriage market may be hit by the same income shocks. These shocks should affect both the supply of brides and, possibly, the supply of grooms. These changes may affect the equilibrium bride price payments. Corno, Hildebrandt and Voena (2020) show under what conditions a negative aggregate income shock may raise child marriage in a bride price economy.

4 Data and Descriptive Statistics

In this section, we describe the main sources of data used in the empirical analysis and in the structural estimation.

4.1 Marriage and bride price data

Our first source of data is the Kagera Health and Development Survey (KHDS), a survey designed by the World Bank and the University of Dar es Salaam in the Kagera region, Tanzania. The Kagera region is located in the north-western corner of Tanzania, covering an area of 40,838 square kilometers, out of which about 30% are covered by the waters of Lake Victoria. The KHDS involved 6 rounds of data collections between 1991 and 2010, creating a 19-years panel dataset. The survey elicits information among 6,353 individuals living in 51 villages (or clusters) for the first time in 1991 and then again in 1992, 1993, 1994, 2004 and 2010, irrespective of whether they had moved out of the original village, region, or country, or were residing in a new household. Excluding those who died, 85% of the respondents surveyed at baseline were re-interviewed in 2010.[6]

Several features make this dataset particularly appropriate for studying the correlation between bride price payments and marital outcomes. First, the last two waves of the survey (2004 and 2010) elicit detailed retrospective information on marriage, including the date of marriage, the crucial variable for our analysis, as well as all the cash and in-kind transfer amounts from the groom's family to the bride's family and vice-versa at the time of marriage. To the best of our knowledge there are no other publicly available datasets eliciting information on bride price amounts.[7] Second, the survey elicits information on the household's composition of each respondent. We can therefore test how the probability of early marriage in response to adverse income shocks changes depending on the number of brothers and sisters each respondent has. Finally, information on respondent's migration from her village of birth allows us to track where the individual lived as a child rather than her current residential location. We can therefore rely on our measure of weather shocks, computed at village level during a respondent's childhood, even if she migrated at the time of marriage. This information is particularly relevant for our purpose given that in Tanzania patrilocal exogamy is the practice: bride moves to the groom's family at the time of marriage. Having data on where the bride was living as a child, allows to measure shocks that affected the family of the bride but not the one of the groom or, more generally, the marriage market.[8]

[6]For additional information on the KHDS see De Weerdt et al. (2012).

[7]Data on bride price payments are mainly collected through *ad hoc* households' surveys on specific projects. For example, Mbaye and Wagner (2017) used data on marriage payments in Senegal, collected as part of the program evaluation of a rural electrification initiative by the UNDP, to test the correlation between bride price and fertility decisions. Lambert, van de Walle and Villar (2018) collected bride price data in Senegal to analyze marital trajectories and women's well-being.

[8]Respondents movements between clusters have been traced using the three following information in the survey: i) the cluster at the time of the interview in each wave of the KHDS; ii) the number of migration and year of migration and iii) the year of birth. We combine this information to obtain the cluster of residence in different year of the respondent's life cycle. More specifically, if the individual never moved, the cluster of residence is equal to the current cluster (63.5% of the sample); if the individual moved once, we used information on the year of migration and data on cluster in the previous waves to identify cluster of residence during youth (26.15% of the sample); if the

Our main outcome variable - the year of marriage - has been collected retrospectively: each married respondent is asked to recall the year when they were first married. In 2004, this information was elicited during the survey, in 2010 instead the research team primarily used phone interviews.[9]

The age of marriage has been computed by taking the difference between the year of marriage and the year of birth, given that the survey does not elicit information on the month of marriage. Thus, unfortunately, some measurement error is to be expected. For example, individuals that are recorded to be married at the age of 18 could have been married instead at the age of 17, if the month of wedding is before the month of birth in the calendar year. Given that the age of marriage does not change across survey rounds, in our empirical analysis we keep only the latest wave in which each individual has been interviewed. We therefore work with a cross-sectional dataset where the majority of the respondents (97.76%) have been interviewed for the last time in 2010 and a small portion (3.24%) have been surveyed for the last time in the 2004 wave.

Our final sample with non-missing information on the age of marriage and on the variable capturing weather shocks (described in the next section) includes 1,246 married individuals, aged 18-46, born between 1965 and 1991.

[Insert figure 1]

In Tanzania, the legal minimum age of marriage for boys is 18, while girls are legally eligible to marry at 15. However, either gender can marry at 14 with court approval. The current minimum age of marriage was established by the Law of Marriage Act (LMA), adopted in 1971. The LMA governs all matters pertaining to marriage, including the minimum age of marriage, divorce procedures, and guidelines for the division of property following dissolution of marital union (USAID, 2013). In our data, we defined child marriages as a union where at least one member got married at the age of 18 or younger. Figure 1 shows the distribution of ages of marriage separately for men and women. The average age of marriage for women is approximately

individual moved more than once then we know his/her position only after the last migration (6.64% of the sample); lastly, when there is missing information about the migration year/s, we can only record individual's current cluster (3.71% of the sample).

[9] For additional information on the construction of the wedding data and for download the dataset see https://www.uantwerpen.be/en/staff/joachim-deweerdt/public-data-sets/khds/

20 years, while the average age of marriage for men is 24 years. As shown in the graph, a sizable portion of women marry during their teenage years, while typically fewer men do so. In particular, approximately 4% of the respondents got married in the year they turned 15 (6% among women and 0.7% among men) and about 21% of the sample reported an age of marriage below or equal to 18 years (5% among men and 30% among women).

[Insert table 1]

The other key variable for our analysis is the bride price. The bride price payment includes any transfer in cash, in livestock and in-kind made to the parents, grandparents, brothers, aunts and uncles of the bride at the time of marriage.[10] The bride price is paid both in formal and informal marriage. Informal marriages in Tanzania include arrangements in which the couple starts to live together and, after a certain period of time, approach the relevant family members to formalize the marriage. In informal marriages, it is common for the groom to pay a "fine" for taking a bride without her family's consent, which is considered as a type of bride payment (Kudo, 2015). As shown in table 1, column 1, a large share of married individuals (82%) reported that a bride price was paid at the time of marriage. The average amount of bride price payment in our sample is 97,335.15 Tanzanian Shilling (about 42 USD).[11] By comparison, median annual household expenditure on durable goods in our KHDS sample is equal to 88,000 Tanzanian Shillings and median expenditure on medication and other health-related expenses is 11,000 Tanzanian Shillings. In the empirical analysis, we deflated the bride price amount with the Consumer Price Index recorded in Tanzania in the year of marriage by using 2010 as a base year (The World Bank, 2015). Looking again at table 1, column 1, we note that the highest fraction of bride price is paid in cash (57%) and bride's parents are the principal receivers of the transfers. When splitting the sample between respondents who got married before or in the year turning 18 (column 2, table 1)

[10]In our data, in-kind payments include clothes, blankets, banana, beers, raw meat, sugar, cooking oil, milk, tea, hand tools, and kerosene.

[11]Respondents were asked to report the corresponding cash value in Tanzanian Shilling of bride prices paid in-kind or in livestock. A median amount of 97,335.15 Tanzanian Shillings in 2020 real terms corresponds to 42 USD in 2020, 17% of the per capita GDP of Kagera. In the region of Kagera, per capita GDP in 2010 is 559,070 Shillings (http://tanzania.opendataforafrica.org/TZSOCECD2016/social-economics-of-tanzania-2016?region=1000190-kagera&indicator=1002980-gdp-per-capita-at-current-prices-tshs, last accessed February 8, 2021).

and after 18 (column 3, table 1), we note that the bride price payment is higher for individuals who got married older. To further examine the dynamics of the bride price, we estimate the profile of bride price payments over a women's age of marriage in the KHDS data, shown in figure 3. The intercept is the mean natural logarithm of bride price payment at age 14. The growth rate of bride price by age is estimated as a fourth-degree polynomial without controls, with controls for the woman's education - dummies for primary, secondary and tertiary education - (specification #1); adding controls for parental assets at the time of marriage - livestock - (specification #2); adding wedding year dummies (specification #3) and parental education - primary and secondary or above - (specification #4).

By matching our data based on the ethnic group of the household head with the *Ethnographic Atlas* (1967) by George Peter Murdock (Murdock, 1967), a database that provides information on the cultural norms and practices of different tribes around the world, we found that in all the ethnic groups in our sample the bride price custom is a common practice in marital arrangements. Hence, unlike Ashraf et al. (2020) and in Corno, Hildebrandt and Voena (2020), we cannot exploit variation in ethic origin to isolate the effect of bride price on outcomes. Thus, we will construct a structural model to disentangle the role of bride price from that of the economic costs associated with raising a daughter and the household's preferences for different ages of marriage.

[Insert table 2]

Table 2 shows summary statistics for the main variables of interest in our sample. Panel A reports the mean and standard deviation of the variables related to the marriage markets, previously discussed. Panel B shows demographic characteristics of the respondents in our sample. More than half of the sample are women and only 17% of the respondents live in urban areas. Approximately 87% (72%) of the respondents have a mother (father) with primary education, while only 4% (18%) of them report a mother (father) with secondary education or higher. 20% of the respondents live in inadequate houses, with floor, walls and roof made by mud, bamboo tree or earth. The average total and food consumption per capita in the past 12 months is equal to 501,329.1 Tzs (about 223.2 USD) and 370,170.4 Tzs (about 164.8 USD), respectively.

Food and total consumption are used in natural logarithm in the empirical analysis. Looking at the household's composition, the average household size is approximately five members and each respondent has on average 1.8 sisters and 1.2 brothers.

4.2 Rainfall shocks

In Tanzania, almost 80% of the labor force (15-64 years) is employed in the agricultural sector. At 90%, the ratio of females engaged in agriculture work is even higher (International Labor Organization, 2013). The Kagera region is not an exception. In our sample, 83% of the respondents do mention agriculture as one of the main activities carried on in the household. The main cultivated crops are banana (53.3%), coffee (about 12%), maize (11%) and cassava (9.6%). Agricultural practices strongly depend on weather patterns; therefore, variations in rainfall may result in large fluctuations in income and consumption for Tanzanian households. Because the Kagera region is bordering with Lake Victoria, Africa's largest lake, natural hazards may include both flooding and drought.

We therefore use estimates on rainfall precipitations as a source of exogenous variation for income shocks.[12] Rainfall data come from the Modern-Era Retrospective analysis for Research and Applications (MERRA) database at the NASA Langley Research Center, USA. MERRA is a global gridded dataset based on retrospective analysis of historical weather data obtained from a combination of weather stations as well as satellite images on the density of cold cloud cover, a reliable proxy for actual rainfall precipitation. The dataset provides daily precipitation (in millimeters) aggregated into 10 grids that are $1/2°$ in latitudes $* \; 2/3°$ in longitude, approximately corresponding to areas of 55∗75 km at the equator. Daily precipitation from 1981 to 2010 are linked to our 51 villages (or clusters), where the respondent lived as a child, through GPS coordinates.

We construct our measure of rainfall shock as follows. For each village, we compute the historical mean level of annual precipitations (in millimeters) during the growing seasons in Kagera (March, April, May and October, November, December) between 1981 and 2010. The growing season is the time of the year when weather variations matter most for cultivated plants to growth

[12] The use of weather variations as proxy for income shocks in developing countries is widespread in the literature. See Miguel, Satyanath and Sergenti (2004), Björkman-Nyqvist (2013), Dustmann, Fasani and Speciale (2017) among others.

and therefore for households' consumption and income.[13] We then compute rainfall deviations (in millimeters and in absolute values) from the rainfall historical mean. Our measures of rainfall shocks, called "$Rainfall\ \ Shock,\ \ Age\ \ \ a_{i,v,y}$" is the absolute value of rainfall deviation from the historical mean of annual precipitations during the growing seasons experienced at age a, by individual i, living in village v, born in year y. For example, the variable *Rainfall Shock at Age 18* measures the difference (in absolute value) between the yearly millimeters of rainfall during the growing seasons in the village of residence of the respondent when she/he was 18 and the historical mean of rainfall for the same village during the growing seasons. By using this measure of rainfall shocks, we aim at capturing anomalously high and low rainfall realizations relative to what is typically experienced in a particular location. Similarly, we compute measures of average rainfall shocks within some age ranges: 8-18 and 15-18, 16-18, 17-18. Therefore, the variation in our measure of rainfall shocks comes from a combination of 10 grids, 51 villages (or clusters) and 27 cohorts (1965 to 1991). This combination generates, for example, 183 different shock realizations at the age of 18 across 1,246 individuals.

[Insert figure 2]

The historical annual mean level of precipitation during the growing seasons is about 878 millimeters per year. As comparison and to check the reliability of rainfall data for Kagera region, Virginia (USA), a state of a similar size as Kagera (42,774.93 kilometer squared) records an average yearly rainfall precipitation of 1100.33 millimeters (NOAA - National Centers for Environmental Information). In figure 2, we report the yearly average level of rainfall in the growing seasons for each year across the 51 villages in our sample. The figure shows considerable variation above and below the historical rainfall average. The mean and the standard deviation of our measure of rainfall shocks in respondent's life cycle is reported in table 2, panel C.

[Insert table 3]

[13]Northern Tanzania has a long rainy season (*Masika*) and a short rainy season (*Vuli*). In the long rainy season, planting starts in February/ March, and harvest is in July/August. During the short rainy season planting is around October/November and harvest is in January/February.

In table 3, we investigate the relationship between weather shocks and consumption. Specifically, we test the effect of our measure of rainfall shocks - the absolute values of rainfall deviation from the historical mean in the growing season - on the natural logarithm of total annual per capita consumption (columns 1-5) and per capita food consumption (columns 6-10) using the entire KHDS panel dataset from 1991 to 2010. We run OLS regressions with year and village fixed effects.

Note that our measure of rainfall is computed between March and May and between October and December of a given year, while consumption is measured over the 12 months before the survey took place, that is between March and December. We therefore expect rainfall shocks in period $t-1$ to be more likely to influence consumption recorded in year t relative to rainfall shocks measured in year t. Results reported in table 3 show indeed that rainfall shocks at $t-1$ are negatively correlated with the measure of consumption in our data at t. In term of magnitude, one standard deviation increase in our measure of rainfall shock (mean= 127.42, sd=99.48) decreases yearly total consumption by 3.4 percentage points (column 2) and yearly food consumption (column 7) by 4.4 percentage points. The coefficient on rainfall in $t-1$ is statistically significant at 5% level in all the specifications, suggesting that negative rainfall shocks are important determinants of resources, and that they are not fully insured by the household, as they are transferred into consumption change. The lack of a statistically significant relationship between rainfall shock in the current period and consumption suggests that households were likely not yet hit by the consequences of the contemporaneous adverse shock when answering the retrospective question about consumption. In columns 4-5 and 9-10 of table 3, we include in the specification the current, the previous and the shocks in the following year and show a statistically significant correlation only between weather shock at time $t-1$ and consumption measured retrospectively at time t. Various alternative measures of weather variation were explored (i.e., proportional change in rainfall from the previous year; the growing degree days (GDD) variation from its historical mean in each cluster) but these measures are not as strongly correlated with consumption as the ones we used among the households in our sample.[14]

[14] The growing degree days (GDD) is a measure of heat accumulation and it is used, for example, to predict when crop reach maturity.

5 Empirical Strategy

The empirical analysis of the effects of social norms on individual's outcomes (i.e. age of marriage) is typically complicated by the endogenous nature of the social norm itself. First, unobserved individual's characteristics, such as physical appearance and cleverness may simultaneously influence the amount/existence of the bride price and the age of marriage, thus providing a spurious correlation between social norms and outcomes. Second, age of marriage is likely to influence the amount of a bride price, again providing a biased estimate of the effect of bride price payments on the age of marriage. For this reason, we exploit exogenous variation in weather shocks across villages and years of birth in Tanzania to study the causal effects of income shocks on the probability of girls and boys being married by the year they turn 18 or before. Specifically, we estimate the following linear probability model:

$$Y_{i,v,y} = \alpha + \sum_{a} \beta_a Rainfall\,Shock\,,\,Age\,a_{i,v,y} + \lambda X_{i,v,y} + \delta_v + \gamma_y + \epsilon_{i,v,y} \tag{1}$$

where $Y_{i,v,y}$ takes value 1 if person i, in village v, born in year y, got married in the year she turns 18 or before, and 0 otherwise. $Rainfall\,Shock,\,Age\,a_{i,v,y}$ is our proxy for income shocks experienced at different ages and it is computed as the absolute values of the rainfall deviation from the historical mean in each village. $X_{i,v,y}$ is a set of individual controls which include dummies for the highest level of education of respondent's mother and father; a dummy equal to one if the respondent lives in urban area and a dummy for an inadequate type of dwelling.[15] Village fixed effects (δ_v) and year of birth fixed effects (γ_y) are included in the estimating equation, to capture time-invariant village characteristics (e.g., richer versus poorer villages) and time-invariant cohort characteristics (e.g., marriage reforms in some particular year) that may be related to the probability of early marriages.

Our coefficients of interest are the β_as, which capture how income shocks affect the probability of marrying before or at age of 18: a positive coefficient indicates that an adverse income shock

[15] The type of dwelling is described by the floor, the roof and the construction material of outside walls. Inadequate dwellings are those with wall, floor and roof made by mud, bamboo tree or earth; good dwellings are those with wall, floor and roof made by iron, stone or cement.

increases the probability of child marriage. We estimate equation (1) using OLS with standard errors clustered at the village level. We report results for the sample of married individuals, separately for women and men.

6 Empirical Results

6.1 Child marriages and income shocks

[Insert table 4]

Table 4 reports the estimated coefficients for equation (1) separately for females (columns 1-2) and males (columns 3-4). The results are striking: girls exposed to adverse rainfall shocks during the age between 8 and 18 years old are more likely to get married before their 18^{th} birthday. In terms of magnitude, a one standard deviation increase in the variable capturing negative rainfall shocks during early ages (relative to the historical local mean) is associated with a 0.1 percentage points higher probability of early marriage and the effect is significant at 5% level (column 1). This finding is robust to the inclusion of controls for parents' education, a dummy indicating if the respondent resides in urban area and an index capturing whether the respondent lives in an inadequate house, computed using the principal component analysis (column 2). Among the controls, it is interesting to note that the coefficient on mother secondary education and above is negatively and statistically significant correlated (at 1% level) with early marriages, suggesting that mother's education is an important driver for better marriage outcomes for girls. In columns 3 and 4 we show the effect of adverse rainfall shocks on early marriage's probability for boys. Boys exposed to negative rainfall shocks between 8 and 18 years of age are less likely to be married before or in the year turning 18, but the coefficients on shocks are not statistically significant, suggesting that adverse economic conditions during adolescence do not influence the marriage' outcomes of young males.

[Insert table 5]

In tables 5 and 6, we focus on marriages and shocks that happened between 15 and 18 years, given that the highest fraction of child marriages in our sample is within this age range (only about

2.7% of marriages happened before 15 years) (see figure 1) and so our estimates are computed on a larger sample. Specifically, in table 5 we focus on females and in table 6 we look at the sample of males. In column 1 of table 5 we investigate the average effect of adverse rainfall shocks that happened when a girl was 15, 16 or 18 years old on the likelihood to be married between 15 and 18 years old. Girls exposed to adverse rainfall shocks between 15 to 18 years of age have a higher probability of being child brides. In terms of magnitude, a one standard deviation increase in the rainfall shock (a decrease or an increase in rainfall relative to the historical local mean) is associated with a 0.09 percentage points (corresponding to 34% increase relative to the mean) higher probability of early marriage and the effect is precisely estimated at 1% level. In column 2, we separately look at the effect of rainfall shocks at 15, 16, 17 or 18, showing that negative rainfall shocks are always positively correlated with early marriage for women and the magnitude of the coefficient monotonically increases, although statistically significant only for shocks at 17 and 18 years, when we observed a greater number of marriages in our sample. In columns 3-6 of table 5, we look at the influence of shocks restricting the sample to marriages that occurred between 16 to 18 years of age (columns 3-4) and between 17 to 18 (columns 5-6). In all the specifications, income shocks during adolescence generate a higher probability of early marriages for girls.

[Insert table 6]

The results for the sample of males are reported in table 6. In stark contrast and confirming the findings in table 4, adverse income shocks do not influence the likelihood of child marriages for boys: almost all the coefficients on rainfall shocks are negative but not statistically significant. This gender asymmetry is consistent with evidence from the same region in Tanzania showing that parental death affects the timing of marriage of girls, but not of boys (Beegle and Krutikova, 2008). Björkman-Nyqvist (2013) also found that, in Uganda, a negative income shock has an adverse effect on the test scores of female students while boys are not affected, a finding consistent with a model where parents' values of child labor and productivity differ across genders.

Our main takeaway from tables 4-6 is therefore that adverse income shocks during adolescence lead to an increase in the probability of child marriages for girls but not for boys. The findings are in line with our theoretical framework and seems to fit well with the conjectured theory: households hit by negative income shocks have a higher marginal utility of consumption and are more likely to marry off their daughters to receive the bride price transfer from her future groom. Income shocks do not affect marriage's decisions of boys: they may be inclined to marry less (given that they have to pay a bride price) but this effect is not statistically significant different from zero. Given that shocks are idiosyncratic and society are virilocal, girls move at marriage after finding a suitable groom, able to pay for the bride price. In the next section, we attempt to provide some empirical evidence on the role played by bride price payments in shaping early marriages decision among poor households in Tanzania. We will then show some descriptive statistics on migration patterns for girls at time of marriage.

6.2 Child marriage and income shocks by bride price's amount

Do bride price payments play a role in the observed positive relationship between income shock and girls' early marriages? One of the great advantages of the KHDS is that it elicits information on bride price amount. This information allows us to investigate whether the relationship between income shocks and age of marriage can be partly explained by the custom of the bride price. In particular, we exploit three questions in the survey: the first one asks to married respondents or to respondents who have been married at least once if there were any payments agreed and made for the marriage on behalf of the groom to the bride's family, including parents, but also brothers, aunts, uncles and grandparents; the second one investigates how much was it worth and the third one elicits the year of marriage. To partially circumvent the endogeneity problem coming from the direct estimation of bride price payment on child marriage, we construct a variable called *Village average bride price, age a,* capturing the average bride price amount received by the women living in the same village of the respondent and married when the respondent was between 8-18, 15-18, 16-18 and 17-18 years, respectively. The idea behind this newly-constructed variable is that the bride price amount received by the women in the same village as the respondent may provide an indication to parents on how much they can get by marrying their daughter at a certain age, without being directly correlated with their daughter's characteristics (e.g. education, physical appearance, etc.). Different from the strategy used by Ashraf et al. (2020) and Corno, Hildebrandt and Voena (2020) we cannot exploit variation in ethnic origin to isolate the effect of bride price on outcomes given that the great majority of the respondents (64%) belong to the same ethnic group (Haya).

[Insert table 7]

In table 7 we augmented the main equation (1) with the interaction between rainfall shocks in a women's life cycle and the bride price amount received by the women living in the same village as the respondent and married when the respondent was between 8-18, 15-18, 16-18 and 17-18 years, respectively. Results in columns 1-3 show that the interactions between adverse shocks and the bride price amount of the neighboring woman are positive in all the specifications and statistically significant when focusing on shocks that happened between 8-18 years old. This finding suggests that girls exposed to income shocks and living in villages where the average bride price is higher have a higher probability of being child brides. In terms of magnitude, a one standard deviation increase in our constructed variable Village bride price, age 8-18 increases the probability of early marriage for girls in Kagera by 0.19 percentage points (column 3). Looking at the standalone variables, we note that, the coefficient on the shocks also remain positive and statistically correlated with the probability of early marriage. In all the specifications, the *Village average bride price, age a* are negatively correlated with the probability of early marriage (although not always significant), suggesting that, when rainfall is at the historical mean, communities with higher average bride price have lower rates of early marriage. Although with less precision, the results are similar when looking at the probability of marriage between 15-18 years (columns 4-6), between 16-18 (columns 7-9), between 17-18 (columns 10-12). To control for household wealth, in columns 3-6-9-12 of table 7 we add household consumption at the time of the survey and the interaction between household consumption and rainfall shocks at 8-18, 15,-18, 16-18, 17-18, respectively, as additional controls, to control for differential economic development across villages with different level of bride price.

Overall, these findings point in the direction of interpreting the bride price as a source of insurance for households exposed to income shocks in the presence of capital markets imperfections.

6.3 Child marriage and income shocks by household's composition

We next explore what factors influence the responsiveness of child marriage to income shocks. In particular, we investigate whether our main effect changes depending on respondent's household composition, i.e. mainly the number of sisters and brothers. We exploit the information in the KHDS related to the relationship each respondent has with the household head (i.e. head, spouse, son/daughter, grandchild, siblings, father/mother, niece/nephew, son/daughter in law, siblings in law, tenant, other relative). We focus on the sub-sample of sons and daughters in each wave and compute the number of sisters and brothers during respondent's teenage years. We then test how the effect of rainfall shock on early marriage's probability varies depending on the household's composition. Indeed, depending on the number of sisters and brothers in the household, a female respondent can be more or less insured against income shocks. For example, a girl with at least one sister is in principle more insured against early marriage given that the sister can be married instead of her.[16]

[Insert table 8]

Table 8 reports the estimated coefficients for equation (1) for women, augmented with the interaction between rainfall shocks at different ages and the number of sisters and brothers for the individual i, controlling for the size of the household. As show in table 2, in the sub-sample used in this analysis, the average number of sisters (brothers) is 1.8 (1.4) respectively, with a minimum of 0 (0) and a maximum of 11 (7) sisters (brothers). In column 1, table 9, we focus on the average rainfall shocks that happen when the girl was between 15 and 18 years. The coefficient on the interaction term $RainfallShock, age15-18$*# $of\ sisters$ is negatively correlated with the respondent's probability of marriage before turning or at 18 years and statistically significant at 5 percent level, suggesting that individuals with sisters are more insured against income shocks and less likely to be married earlier: in case of income shocks, there is a higher number of potential brides to count on. The coefficient remains negative in columns 2 and 3 and, in the latter, it

[16]It would be interested to also test whether the number of younger versus older sisters/brothers would have had a different effect on respondent's probability of child marriage. Unfortunately, given the already small sample size, we cannot exploit this additional heterogeneity.

is statistically significant at 1 percent level. On the contrary, having brothers does not seem to influence early marriage's probability. In columns 2 and 3 we focus on marriages that happens between 16-18 and 17-18, respectively: the interaction between rainfall shocks and number of sisters is always negatively correlated with child marriage (although in column 2 is not statistically significant). Finally, as expected, girls living in a more numerous household are more likely to be child brides.

6.4 Marriage market

Finally, we investigate the correlation between rainfall shocks in the respondent's life cycle and the amount of the bride price payment in our sample. Variation in bride price amount by cluster is reported in figure A1. If households hit by the shock are in the same marriage market we should observe a negative correlation between the shock and the bride price amount: a higher supply of brides would be associated with lower bride price payments.

[Insert table 9]

This does not seem to be the case in our data. As reported in table 9, in all the specifications, the coefficient on negative rainfall shocks at different ages is not statistically significant, suggesting that, in line with the setup of the model, we seem to identify idiosyncratic shocks to households that do not affect the overall marriage market.

Further evidence on the fact that the idiosyncratic shocks we are exploiting do not influence the overall marriage market comes from the descriptive statistics on migration patterns at marriage. The survey investigates the number of difference places where the respondent lived since 1994 and the main reasons for moving.[17] First, we observe that migration is a common phenomenon in Kagera: 55.31% and 43.26% of women and men in our sample migrated since 1994. Second, in the appendix, table A1 panel A, we report the main reasons for migration by gender and show that nearly 64% of women declare that marriage is the main reason for migrating compared to

[17] The exact question in the KHDS is "Now I would like to ask you about the different places in which you lived since 1994. I'd like to know how many times you have moved since 1994, but excluding moves within the same village/town/city and excluding short-term stays of under six months" and "What was the main reason for moving?".

only 9% of males. This is due to the practice of virilocality: brides, after marriage, move to live with their groom's family, suggesting that spouses generally do not come from the same village. Third, it is interesting to note that the fraction of women reporting marriage as the main reason for migration is higher among those who married before or in the year turning 18 compared to those who married older (table A2, panel B). Finally, using the same dataset, Hirvonen and Lilleør (2015) also documents that the end of a marriage is the main reason for return migration to a woman's village of origin.

6.5 Robustness

In this section, we conduct a series of robustness checks to validate our main results reported in tables 4-6. In the appendix, table A2, we check the robustness of our findings by augmenting equation (1) with negative rainfall shocks that occurred later in life and in particular few years after the age of 18. If our main results are not driven by spurious correlations, we should not observe any statistically significant impact of adverse rainfall shocks that hit a girl *after* she turned 18 on her prior marriage probability. This is exactly what we find in table A2: while on one hand, we confirm that women exposed to negative income shocks at 15-18 (column 1), 16-18 (column 2) and 17-18 (column 3) years old have a higher probability of marrying younger, on the other hand, we do not observe any influence of negative income shocks that happened after 18 years on girls' probability to get married by their 18th birthday. In the last three columns of table A2, we report the same results for the sample of boys. As in our main specification, adverse rainfall shocks both before and after 18 years do not appear to influence the likelihood of early marriages for boys.

As further robustness test, in table A3 in the appendix, we check whether our measure of negative rainfall shocks is correlated with the probability of being married between 13-14 (columns 1-3) and between 14-15 (columns 4-7), hence *before* the shock occurs. As in the previous table, negative shocks that hit individuals at certain ages should not influence her prior marriage's probability. For both girls (columns 1-5) and boys (columns 6-7), negative rainfall shocks at 15 to 18 do not influence the probability of marriage at 13-14 and shocks at 16 to 18 do not affect the likelihood of marriage at 14-15. Given the small number of marriages at 13-14 for boys, we cannot estimate the coefficients reported in columns 1-2 for the sample of males.

Finally, in table A4, we study the persistence of the effect of income shocks on marriage probability. In particular, we look at the probability of marriage by 19-20 (column 1), 20-21 (column 2), 22-23 (column 3) years. We show that the effect of adverse rainfall shocks in a women's life cycle do not persist at later marriages (marriages that happen after 18) and also do not appear to delay marriage to later ages for men (column 4-6).

7 Structural estimation and policy counterfactuals

In this section, we estimate the parameters of the model described in section 3. We use the estimates to perform counterfactual simulations that allow us to assess the role of child marriage and of bride price in smoothing households' consumption in response to adverse economic shocks.

7.1 Parametrization

The utility function for all the households is set to be a CRRA with coefficient of relative risk aversion b:

$$u(c) = \frac{c^{1-b}}{1-b}.$$

Income y_a follows an i.i.d. log-normal distribution with mean μ and variance σ^2. Consistently with what we observe in the KHDS data, μ is fixed and does not vary with age.

[Insert figure 3]

We set the utility benefit associated with marriage at age a, denoted as ξ_a, as sixth-degree polynomial in years since age 14 ($\alpha = a - 14 + 1$):

$$\xi_a = \sum_{i=0}^{6} k_{i+1}\alpha^i.$$

The bride price amount BP_a is computed from the data as a polynomial in a woman's age.

We restrict marriage to occur between age 14 and age 34, since few marriages occur outside of this interval.

7.2 Structural estimation

We estimate the parameters $\boldsymbol{\theta} = \{b, \delta, \mu, \sigma^2, \{k_1, ..., k_7\}\}$ by indirect inference (Gourieroux, Monfort and Renault, 1993). We construct an auxiliary model (whose parameters we denote as $\boldsymbol{\phi}$), and estimate its empirical counterpart in the KHDS data ($\hat{\boldsymbol{\phi}}^{data}$). We then find the structural parameters that solve the following problem:

$$min_{\boldsymbol{\theta}}(\hat{\boldsymbol{\phi}}^{data} - \boldsymbol{\phi}^{sim}(\boldsymbol{\theta}))G(\hat{\boldsymbol{\phi}}^{data} - \boldsymbol{\phi}^{sim}(\boldsymbol{\theta}))'. \tag{2}$$

The vector of estimated parameters of the auxiliary model comprises of three components. First, we target the vector of probability of marriage by each age between 14 and 34: $\boldsymbol{\phi_1} = \{P(M_a = 1)\}_{a=14}^{34}$. In our model, each of these probabilities is equal to:

$$\begin{aligned} P(M_a = 1) &= 1 - \prod_{\alpha=14}^{a} P(m_\alpha = 0) \\ &= 1 - \prod_{\alpha=14}^{a} P\left(\frac{(y_\alpha \cdot (1+e))^{1-b}}{1-b} + \delta E[V^0_{\alpha+1}] > \frac{(y_\alpha + BP_\alpha)^{1-b}}{1-b} + \delta E[V^1_{\alpha+1}] + \xi_\alpha\right). \end{aligned}$$

Second, we set two parameters of the auxiliary model as the elasticity of female teenage marriage to consumption shocks at age 17 and 18. In the model, we estimate the following model as a linear probability model

$$P(m_{16,17,18} = 1)_i = \delta_1 + \psi_1 \cdot ln(C_{i,16}) + \psi_2 \cdot ln(C_{i,17}) + \psi_3 \cdot ln(C_{i,18}),$$

where $m_{16,17,18}$ takes value one if the woman marries between ages 16 and 18, $C_{i,a}$ is aggregate consumption of household i with a daughter of age a, hence $C_{i,a} = y_{i,a} + BP_a m_{i,a} = c_{i,a}$.

Then, we set $\boldsymbol{\phi_2} = \{\psi_1, \psi_2, \psi_3\}$.

In the KHDS, we estimate the relationship between the probability of child marriage and rainfall shocks, and scale it by the sensitivity of consumption to rainfall shocks:

$$P(m_{16,17,18})_i = \delta_1 + \beta_1 \cdot Shock\,at\,16_i + \beta_2 \cdot Shock\,at\,17_i + \beta_3 \cdot Shock\,at\,18_i + \boldsymbol{\lambda_1}'\mathbf{X}_i$$

$$ln(C_{i,t-1}) = \alpha + \eta \cdot Shock_{i,t-1} + \boldsymbol{\gamma}'\mathbf{X}_i + \epsilon_{it}$$

$$\boldsymbol{\phi_2}^{data} = \left\{\frac{\beta_1}{\eta}, \frac{\beta_2}{\eta}, \frac{\beta_3}{\eta}\right\}$$

where $\mathbf{X}$ is a vector of year-of-birth fixed effects, cluster fixed effects and socio-economic characteristics of the household that are not captured in the model.

Third, we target the mean and variance of the logarithm of household consumption, $\boldsymbol{\phi_3} = \{E[ln(C)], Var[ln(C)]\}$, where:

$$E[ln(C)] = E[ln(y + BP \cdot m)]$$

$$Var[ln(C)] = E[(ln(y + BP \cdot m) - E[ln(C)])^2].$$

Hence, the vector of parameters of the auxiliary model combines these three sub-vectors as $\boldsymbol{\phi} = \{\boldsymbol{\phi_1}, \boldsymbol{\phi_2}, \boldsymbol{\phi_3}\}$. The weighing matrix in the estimation is given by the inverse of the variance-covariance matrix of the empirical estimates of the parameters of the auxiliary model $\hat{G} = Var[\boldsymbol{\phi}^{data}]^{-1}$ computed by block-bootstrap, where each village is a block.

[Insert figure 4]

Figure 4 reports the estimated parameters of the auxiliary model in the KHDS data (with the 90% confidence interval) and the corresponding estimates from the data simulated by the model. The model closely replicates the targeted distribution of marriage age (parameters 1-20, or $\boldsymbol{\phi_1}$) and the distribution of log-consumption (parameters 25 and 26, or $\boldsymbol{\phi_3}$). The model also accounts for a large fraction of the response of the probability of marriage with respect to rainfall shocks at ages 16, 17 and 18 (parameters 22, 23, and 24 or $\boldsymbol{\phi_2}$), but not for the whole response. This is also due to the fact that these moments are more noisy, as can be seen from the wide confidence intervals, and hence receive relatively lower weight in the optimal weighting matrix.

[Insert Table 10]

Table 10 reports the estimates for vector $\boldsymbol{\theta}$ and their standard errors. We estimate the coefficient of relative risk aversion to be equal to 0.39 and the discount factor equal to 0.36. Given the estimates for $\mathbf{k}$, the resulting values of ξ_a between ages 14 and 34 are positive but small early on, peak at age 21 and then drop after that to then increase again in later ages, after which marriage is no longer possible within the model. In Appendix figure 2, we report the value of ξ_a normalized as a consumption equivalent measure.[18] Daughters contribute to about 5% of household per capita consumption. Estimated average log-income μ is 14.883, which generates a simulated average log-consumption of 14.884. The estimated variance of log-income σ^2 is 0.209, which generates a simulated variance of log-consumption of 0.202.

These estimates indicate that liquidity considerations play a significant role in explaining the prevalence of child marriage: parents prefer later marriages, and daughters are productive. When income is low and hence marginal utility of consumption high, the bride price plays a larger role in causing early marriage.

7.3 Policy simulations

In this section, we study two types of policy simulations that examine the effect of policies meant to discourage child marriage: age bans, under which marriage below a certain age is prohibited, and cash transfer programs, in which households with young daughters receive payments that are unconditional or conditional on the daughter remaining unmarried.

7.3.1 Child marriage bans

A common policy, although often ineffective, to reduce child marriage is to impose bans, that prohibit marriage below a certain age. We examine the implications of this policy by simulating two counterfactual exercises:

a) a child marriage ban that prohibits marriage below the age of 16;

b) a child marriage ban that prohibits marriage below the age of 18.

One interesting implication of banning child marriage is well captured by figure 5, which shows

[18] In the figure, the utility of marriage at age a is expressed as the parameter x_a that solves $\xi_a = \frac{(x_a \cdot exp(\mu))^{1-b}}{1-b}$.

the cumulative probability of marriage at each age without marriage bans and under the two different bans we simulate. After a ban is no longer binding, marriage rates do not increase immediately to the levels they would have been without the ban, but slowly adjust leading to a permanent shift in the average age of marriage, which shifts from 20.7 years old at baseline to 21.1 years old with an age 16 age ban and 21.9 with an age 18 ban. This pattern is due to the fact that the ban on child marriage prevented marriages that would have occurred to smooth income shocks, and these household may not choose to have their daughter marry as soon as she reaches the legal age of marriage. This finding explains why a ban on marriage before age 16 reduces overall marriage before age 18 by 14.6% (or 4.2 percentage points) and why a ban on marriage before age 18 has a persistent effect up to a woman's mid-twenties.

Because child marriage is used by households as a consumption-smoothing mechanism, banning child marriage limits the consumption insurance purpose of marriage. This can make an age ban particularly costly for households, greatly limiting the popularity and the sustainability of the policy. To examine the welfare implications of a marriage age ban, we compute the consumption equivalent(equivalent variation) of the marriage age ban with the formula:

$$\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}\left[\frac{((1+\pi)c_{B,t})^{1-b}}{1-b}+m_{B,t}\cdot\xi_t\right]=\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}\left[\frac{(c_{CF,t})^{1-b}}{1-b}+m_{CF,t}\cdot\xi_t\right] \tag{3}$$

Hence, the consumption equivalent captures the change in lifetime per-capita consumption, over the 28 years of life of the household from age 14 of the daughter onward, that equates the utility of the household at baseline to the utility of the household under the policy.

Age bans have relatively small utility costs, equivalent to -0.140% of the lifetime per-capita household consumption for an age 16 ban and -0.175% of lifetime per-capita household consumption for an age 18 ban.

We consider an alternative scenario, in which the consumption-smoothing effect of child marriage is mitigated by the presence of perfect credit market, by allowing households to borrow and save, by modifying the budget constrain the following way:

$$c_a(s^a) \cdot (1 + e \cdot (1 - M_a(s^a))) + A_{a+1}(s^a) \leq y_a(s_a) + BP_a \cdot m_a(s^a) + (1+r)A_a(s^{a-1})$$
$$A_1(s^1) = A_{T+1}(s^T) = 0.$$

We calibrate the interest rate r to be equal to 12% (Bank of Tanzania, 2010). Allowing for credit markets eliminates the use the timing of marriage as a consumption smoothing device, shifting the distribution of ages of marriage. This reduces the utility costs of marriage bans, making the utility cost of an age-16 ban 4.8 times smaller (0.029%) than in the absence of a credit market, and the utility cost of an age-18 ban 4.3 times smaller (0.041%), as reported in panel B of table 11. This policy exercise indicates that policies that discourage child marriage should be accompanied by policies that improve households' ability to insure their consumption, to balance the potential benefits for the daughter with the costs that the household faces.

7.4 Conditional and unconditional cash transfers

A policy tool that has been used to combat child marriage are cash transfers. Baird, McIntosh and Özler (2011) show that an unconditional cash transfers program targeted to the households of young teenage girls reduces teenage pregnancy and marriage in Malawi. Transfers conditional on remaining unmarried are being studied in India (Sinha and Yoong, 2009). With our model, we can quantify the cost of reducing child marriage through these different policy levers, and assess the utility benefit to households. These are partial equilibrium analyses that cannot account for the effect of the subsidies on prices, and hence should be interpreted in the context of small-scale interventions.

We consider three policies,

1. a conditional program (CCT) that makes a cash transfer to households with a daughter up to age 18 as long as the daughter is unmarried;

2. an unconditional program (UCT) that makes a cash transfer to all households with a daughter up to age 18, irrespective of their marital status

3. an unconditional program (UCT25) that makes a cash transfer to households whose income is below the 25th percentile if the income distribution and with a daughter up to age 18, irrespective of her marital status.

We compute how large each type of transfer ought to be to reduce child marriage by 20%, 50% and by 100%, thereby eliminating the phenomenon entirely. Table 12 reports the relevant amounts.

The simulation suggests that, while cash transfers conditional on remaining unmarried can be very cost-effective at reducing child marriage, a reduction in child marriage can be also achieved with unconditional cash transfers, particularly those targeting the poorest households.

8 Conclusions

Despite widespread condemnation, the practice of child marriages persists around the world. Its consequences, especially among women and their children, are devastating, yet its reasons are poorly understood. In this paper, we examine the responsiveness of child marriage to income fluctuations among rural households in Tanzania, where bride price is customary, and attempt to understand effective policies potential able to reduce the phenomena.

We develop a dynamic discrete-choice model to show that parents who are exposed to adverse income shocks have a higher probability of marrying their daughters earlier, as we confirm using a survey dataset from rural Tanzania and by exploiting variation in rainfall over a woman's life cycle as a proxy for income shocks. Moreover, the relationship between rainfall shocks and child marriages is stronger in villages where the average bride price is higher.

We use these findings, together with the profile of age of marriage and the empirical distribution of consumption, to estimate the parameters of our model and to perform policy simulations. We find that parents prefer to delay marriage and that daughters are productive, hence the bride price plays a crucial role in determining the age of marriage. Child marriage bans, if enforceable, are effective, as they raise age of marriage even after they are no longer binding. They are costly to households, because they prevent relying on bride price payments in times of economic hardship, but the costs are not large. Conditional and even unconditional cash transfers are effective at reducing child marriage, especially when they target low-income households.

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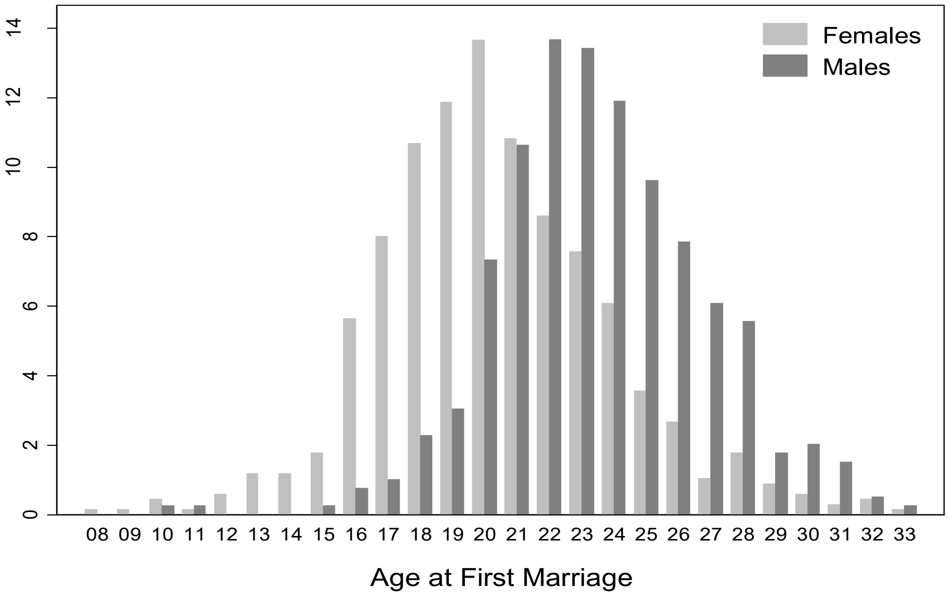
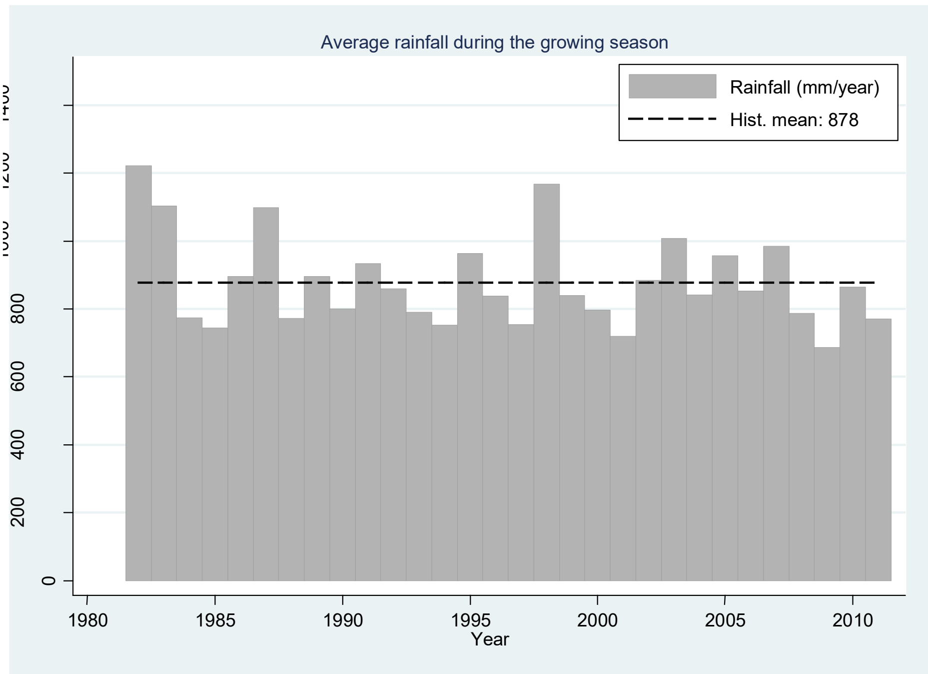
Figures and Tables

Figure 1: Distribution of age at first marriage, by gender



Notes: Sample of respondents with non-missing information on the age of marriage. Distribution of age at marriage in Kagera, Tanzania. Source: Kagera Health Development Survey (KHDS) 2004-2010.

Figure 2: Yearly deviation from historical rainfall mean during the growing season

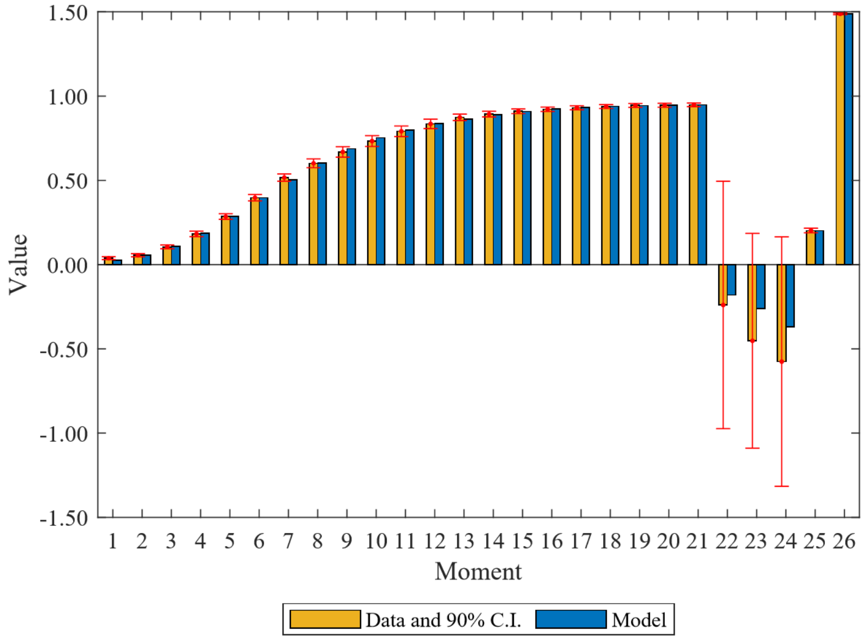


Source: MERRA Database, NASA Langley Research Center.

Figure 3: Average bride price amounts, by daughter's age

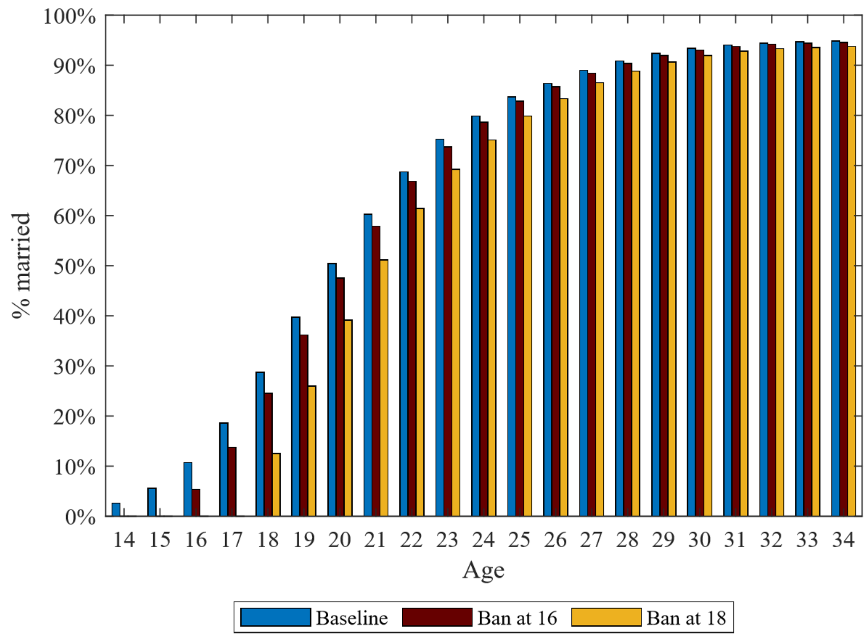
Notes: Sample of respondents with positive bride price payment. The intercept is the mean bride price payment at age 14. The age at marriage is defined between 14 to 33. The growth rate of bride price by age is estimated as a fourth-degree polynomial without controls, with controls for the woman's education (specification #1), with controls for parental assets (specification #2), with wedding year dummies (specification #3) and adding dummies for parental education (specification #4). Source: Kagera Health Development Survey 2004-2010.

Figure 4: Matching of the moments of the auxiliary model



Notes: Moments of the auxiliary model in the data and their 90% confidence intervals, and moments in the estimated model. Moments 1-21 are probabilities of marriage between ages 14 and 34. Moments 22, 23 and 24 are the elasticity of child marriage with respect to resource shocks. Moment 25 is the variance of the natural logarithm of household consumption. Moment 26 is the mean of the natural logarithm of household consumption, divided by 10 for scaling purposes.

Figure 5: Counterfactuals experiment - age bans



Notes: Probability of being married by age, under different counterfactual regimes. The baseline case is the estimated model on the KHDS data. 'Ban at 16' represents a counterfactual in which women are barred from marrying before age 16. 'Ban at 18' represents a counterfactual in which women are barred from marrying before age 18.

Table 1: Characteristics of the bride price payment

	Full sample	*Marriage <= 18*	*Marriage > 18*
	(1)	(2)	(3)
Bride price (%)[a)]	0.82	0.79	0.82
Bride price amount (in TZS)[b)]	97335.15 (42$)	68371.49 (29.5$)	104353.8 (45$)
By Type			
Paid in cash (%)	0.57	0.56	0.57
Paid in-kind (cloths, blankets, banana beer, raw meat, other foods, handtools, keorsene, others) (%)	0.27	0.29	0.26
Paid in livestock (%)	0.07	0.06	0.08
By Recipients			
Paid to bride's parents (%)	0.57	0.56	0.57
Paid to bride's family (aunts, uncles, grandparents, brothers) (%)	0.38	0.42	0.37
Paid to others (not parents, aunts/uncles, grandparents, brothers) (%)	0.05	0.02	0.06

Note: a) Bride price is defined as any payment made by the groom or by the groom's family to parents, aunts, uncles, grandparents, brothers and other family members of the bride for formal marriages and as any fine paid by the groom or by the groom's household for informal marriages. b) Exchange rate: 1US$= 2.314,00 TZS at July 17th, 2020. The values reported in the last three rows of the table are defined for formal marriages only. Source: Kagera Health Development Survey, 2004-2010.

Table 2: Summary Statistics

	Mean	*Std. Dev*	*Min*	*Max*
Panel A: Marriage's characteristics				
Age at marriage	21.960	4.186	8.000	40.000
Marriages from 8 to 15 years	0.039	0.193	0.000	1.000
Marriages from 8 to 18 years	0.196	0.397	0.000	1.000
Bride price	0.815	0.389	0.000	1.000
Bride price amount (in TZS)	97,335.15	133,003.71	0.000	1,005,000.000
Panel B: Demographic characteristics				
Female	0.63	0.48	0.00	1.00
Urban area	0.17	0.37	0.00	1.00
No education (mother)	0.08	0.18	0.00	1.00
Primary education (mother)	0.87	0.21	0.00	1.00
Secondary education and above (mother)	0.04	0.12	0.00	1.00
No education (father)	0.10	0.22	0.00	1.00
Primary education (father)	0.72	0.32	0.00	1.00
Secondary education and above (father)	0.18	0.27	0.00	1.00
Bad House (PCA)	0.20	0.40	0.00	1.00
Total consumption p/c (in TZS)	501329.10	370170.44	50752.83	3329467.00
Food consumption p/c (in TZS)	312740.82	209436.69	25197.17	1600864.00
Number of sisters	1.828	1.792	0.000	11.000
Number of brothers	1.239	1.604	0.000	7.000
Household size	4.982	1.968	1.000	20.000
Panel C: Rainfall Shocks				
Rainfall shock, age 8-18	0.961	0.232	0.64	1.94
Rainfall shock, age 17-18	1.064	0.598	0.15	3.15
Rainfall shock, age 16-18	1.032	0.455	0.208	3.09
Rainfall shock, age 15-18	1.003	0.403	0.298	2.50
Rainfall shock, age 15	0.938	0.892	0.006	3.60
Rainfall shock, age 16	0.986	0.893	0.006	3.60
Rainfall shock, age 17	1.054	0.919	0.006	3.60
Rainfall shock, age 18	1.073	0.961	0.006	4.13
Observations		1,246		

Notes: Sample of respondents with non-missing values for the age at marriage. Rainfall shocks are computed as the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December) at each age of the respondents. Rainfall shocks are multiplied by 100. "Bride price" is equal to 1 if there was a bride price payment made for the marriage; the type of dwelling is described by the construction material of the floor, the roof and outside walls of respondent's household. Bad house (PCA) is the principal components of wall, floor and roof made by mud, bamboo tree or earth (compared to those made by iron, stone or cement). "Total consumption p/c" include the sum of all non-food expenditure (i.e. batteries, soap, umbrella, newspapers, haircuts, etc.) plus expenditure in health, education, funeral and utilities and food consumption of the household divided by the household size in the past 12 months. "Food consumption p/c" is the sum of household food consumption divided by the household size in the past 12 months. Source: Kagera Health Development Survey 2004-2010 for demographic characteristics and NASA Langley Research Center for rainfall measures.

Table 3: Rainfall shocks and households' consumption

Dependent variable:	*Total Consumption p/c (log) (in TZS)*					*Food consumption p/c (log) (in TZS)*				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall shock, t	0.026			0.030	0.030	0.025			0.031	0.031
	(0.024)			(0.024)	(0.024)	(0.028)			(0.027)	(0.027)
Rainfall shock, t-1		-0.034**		-0.037**	-0.037**		-0.044***		-0.047***	-0.042***
		(0.017)		(0.017)	(0.017)		(0.014)		(0.014)	(0.014)
Rainfall shock, t+1			-0.016		-0.000			-0.031		-0.013
			(0.026)		(0.023)			(0.028)		(0.026)
Mean of the rainfall shock	100.3	127.3	97.9	--	--	100.3	127.4	97.9	--	--
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Village Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.678	0.678	0.678	0.679	0.679	0.649	0.650	0.649	0.650	0.650
Number of observations	8,083	8,083	8,083	8,083	8,083	8,087	8,087	8,087	8,087	8,087

Notes: OLS regression on KHDS panel data. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5% , * 10% significance. Constant not displayed. "Total consumption p/c (log)" include the logarithm of the sum of all non-food expenditure (i.e. batteries, soap, umbrella, newspapers, haircuts, etc.) plus expenditure in health, education, funeral and utilities and food consumption of the household divided by the household size in the past 12 months. "Food consumption p/c (log)" is the logarithm of the sum of household food consumption divided by the household size in the past 12 months. The average consumption p/c is 1,239,456TZS (554US$) ; the average food consumption p/c is 833,250.6 TZS (372.5 US$). Rainfall shock is defined as the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each village from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls, as described in table 2, include dummies for mother and father highest level of education (no education, primary education and secondary/tertiary education), the principal component analysis for inadequate house and a dummy indicating urban areas. Source: Kagera Health Development Survey, 1991-2010.

Table 4: Child marriage and rainfall shocks

Dependent variable: 1 if married between 8 and 18 years old				
	Females		*Males*	
	(1)	(2)	(3)	(4)
Rainfall shock between 8 and 18 years old	0.430**	0.424***	-0.089	-0.134
	(0.168)	(0.160)	(0.134)	(0.137)
Urban		-0.153		-0.054
		(0.098)		(0.039)
Bad House (PCA)		0.004		0.003
		(0.016)		(0.007)
Mother Primary Edu		-0.155		0.037
		(0.125)		(0.044)
Mother Secondary Edu and above		-0.489***		0.151
		(0.132)		(0.149)
Father Primary Edu		0.093		-0.002
		(0.111)		(0.040)
Father Secondary Edu and above		0.208*		0.022
		(0.125)		(0.060)
Village Fixed Effects	yes	yes	yes	yes
Year of Birth Fixed Effects	yes	yes	yes	yes
R2	0.108	0.143	0.215	0.231
Observations	674	674	395	395

Notes: OLS regressions. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5% , * 10% significance. Constant not displayed. “Rainfall shocks between 8 and 18 years old” is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December) averaged between the age of 8 to 18. All the coefficients (standard errors) are multiplied by 100. Source: Kagera Health Development Survey 1991-2010.

Table 5: Child marriage and rainfall shocks, sample of females

Dependent variable:	*1 if married bw 15-18*		*1 if married bw 16-18*		*1 if married bw 17-18*	
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall shock, age 15-18	0.242***					
	(0.083)					
Rainfall shock, age 16-18			0.144**			
			(0.066)			
Rainfall shock, age 17-18					0.143***	
					(0.052)	
Rainfall shock, age 15		0.030				
		(0.038)				
Rainfall shock, age 16		0.039		0.016		
		(0.039)		(0.037)		
Rainfall shock, age 17		0.078*		0.064		0.077**
		(0.042)		(0.042)		(0.037)
Rainfall shock, age 18		0.087**		0.069*		0.067**
		(0.038)		(0.035)		(0.027)
Controls	yes	yes	yes	yes	yes	yes
Village Fixed Effects	yes	yes	yes	yes	yes	yes
Year of Birth Fixed Effects	yes	yes	yes	yes	yes	yes
R2	0.153	0.155	0.142	0.144	0.134	0.134
Number of observations	725	725	730	730	735	735

Notes: OLS regressions. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5% , * 10% significance. Constant not displayed. Rainfall is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls, as described in table 2, include dummies for mother and father highest level of education (no education, primary education and secondary/tertiary education), the principal component analysis for inadequate house and a dummy indicating urban areas. Source: Kagera Health Development Survey 1991-2010.

Table 6: Child marriage and rainfall shocks, sample of males

Dependent variable:	*1 if married bw 15-18*		*1 if married bw 16-18*		*1 if married bw 17-18*	
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall shock, age 15-18	-0.060					
	(0.049)					
Rainfall shock, age 16-18			-0.051			
			(0.035)			
Rainfall shock, age 17-18					-0.025	
					(0.018)	
Rainfall shock, age 15		-0.009				
		(0.017)				
Rainfall shock, age 16		-0.008		-0.011		
		(0.014)		(0.012)		
Rainfall shock, age 17		-0.028		-0.024		-0.015
		(0.018)		(0.017)		(0.012)
Rainfall shock, age 18		-0.015		-0.015		-0.010
		(0.015)		(0.014)		(0.013)
Controls	yes	yes	yes	yes	yes	yes
Village Fixed Effects	yes	yes	yes	yes	yes	yes
Year of Birth Fixed Effects	yes	yes	yes	yes	yes	yes
R2	0.204	0.206	0.205	0.206	0.207	0.207
Number of observations	493	493	501	501	511	511

Notes: OLS regressions. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5% , * 10% significance. Constant not displayed. Rainfall is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls, as described in table 2, include dummies for mother and father highest level of education (no education, primary education and secondary/tertiary education), the principal component analysis for inadequate house and a dummy indicating urban areas. Source: Kagera Health Development Survey 1991-2010.

Table 7: Child marriage and rainfall shocks, by bride price of the neighboring women

Dependent variable=	*1 if married before or at 8-18*			*1 if married bw 15-18*			*1 if married bw 16-18*			*1 if married bw 17-18*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Rainfall shock. age 8-18*Village bride price, age 8-18	0.003***	0.004***	0.004***									
	(0.001)	(0.001)	(0.001)									
Rainfall shock, age 8-18	0.326**	0.299*	0.247									
	(0.158)	(0.166)	(0.185)									
Village bride price, age 8-18	-0.003***	-0.004***	-0.003***									
	(0.001)	(0.001)	(0.001)									
Rainfall shock. age 15-18*Village bride price, age 15-18				0.001	0.001*	0.001*						
				(0.001)	(0.001)	(0.001)						
Rainfall shock, age 15-18				0.207*	0.196*	0.126						
				(0.105)	(0.104)	(0.114)						
Village bride price, age 15-18				-0.001	-0.001*	-0.001*						
				(0.001)	(0.001)	(0.001)						
Rainfall shock. age 16-18*Village bride price, age 16-18							0.116	0.092	0.104			
							(0.090)	(0.088)	(0.096)			
Rainfall shock, age 16-18							0.001	0.001	0.001			
							(0.001)	(0.001)	(0.001)			
Village bride price, age 16-18							-0.001*	-0.001**	-0.001**			
							(0.001)	(0.001)	(0.001)			
Rainfall shock. age 17-18*Village bride price, age 17-18										0.001	0.001	0.001
										(0.001)	(0.001)	(0.001)
Rainfall shock, age 17-18										0.116	0.093	0.100
										(0.095)	(0.096)	(0.098)
Controls	no	yes	yes	no	yes	yes	no	yes	yes	no	yes	yes
Village Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year of birth Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.145	0.185	0.204	0.136	0.177	0.194	0.137	0.180	0.196	0.172	0.213	0.230
Number of observations	582	582	580	612	612	610	578	578	577	501	501	500

Notes: OLS regression. Robust standard errors in parentheses, clustered at the village level. *** 1% . ** 5% . * 10% significance. Constant not displayed. Rainfall is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls are described in table 1. The variable village average bride price is the average brideprice amount received by women living in the same village as the respondent married when the respondent was 8-18 (Cols. 1-3), 15-18 (Cols. 4-6), 16-18 (Cols. 7-9), 17-18 (Cols. 10-12). The mean and the standard deviation of the first interaction term are 72.54 and 63.43 respectively. In cols. 3-6-9-12 we also control for household consumption and the interaction between household consumption and rainfall shocks at 8-18, 15-18, 16-18, 17-18, respectively. Source: Kagera Health Development Survey 1991-2010.

Table 8: Early marriages and rainfall shocks by household's composition

Dependent variable:	*1 if married 15-18*	*1 if married 16-18*	*1 if married 17-18*
	(1)	(2)	(3)
Rainfall shock, age 15-18* # of sisters	-0.085**		
	(0.043)		
Rainfall shock, age 15-18* # of brothers	0.025		
	(0.047)		
Rainfall shock, age 15-18	0.446***		
	(0.150)		
Rainfall shock, age 16-18* # of sisters		-0.074	
		(0.047)	
Rainfall shock, age 16-18* # of brothers		0.008	
		(0.035)	
Rainfall shock, age 16-18		0.221	
		(0.163)	
Rainfall shock, age 17-18* # of sisters			-0.042***
			(0.014)
Rainfall shock, age 17-18* # of brothers			-0.014
			(0.019)
Rainfall shock, age 17-18			0.226***
			(0.066)
# of brothers, age 15-18	-0.078		
	(0.056)		
# of sisters, age 15-18	0.031		
	(0.049)		
# of brothers, age 16-18		-0.081**	
		(0.039)	
# of sisters, age 16-18		-0.005	
		(0.052)	
# of brothers, age 17-18			-0.015
			(0.027)
# of sisters, age 17-18			-0.001
			(0.019)
Household size	0.040**	0.044**	0.030***
	(0.018)	(0.019)	(0.011)
Controls	yes	yes	yes
Village Fixed Effects	yes	yes	yes
Year of birth Fixed Effects	yes	yes	yes
R2	0.417	0.446	0.247
Number of observations	258	260	488

Notes: Sample of females. OLS regressions. Robust standard errors in parentheses clustered at the village level. *** 1%, ** 5%, * 10% significance. Constant not displayed. Rainfall is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls, as described in table 2, include dummies for mother and father highest level of education (no education, primary education and secondary/tertiary education), the principal component analysis for inadequate house and a dummy indicating urban areas. Source: Kagera Health Development Survey 1991-2010.

Table 9: Rainfall shocks and bride price amount

Dependent variable:	*Bride price amount (log)*					
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall shock. age 15-18	-0.002					
	(0.218)					
Rainfall shock. age 16-18			-0.127			
			(0.168)			
Rainfall shock. age 17-18					0.022	
					(0.099)	
Rainfall shock. age 15		0.075				
		(0.099)				
Rainfall shock. age 16		-0.068		-0.090		
		(0.092)		(0.087)		
Rainfall shock. age 17		0.035		0.019		0.048
		(0.080)		(0.073)		(0.066)
Rainfall shock. age 18		-0.043		-0.034		-0.018
		(0.061)		(0.060)		(0.058)
Age	0.062	0.062	0.064*	0.062	0.059	0.061
	(0.039)	(0.040)	(0.039)	(0.039)	(0.041)	(0.039)
Primary Edu	0.508***	0.514***	0.511***	0.517***	0.517***	0.515***
	(0.175)	(0.174)	(0.171)	(0.174)	(0.175)	(0.175)
Secondary/Higher Edu	1.237***	1.259***	1.211***	1.228***	1.219***	1.242***
	(0.306)	(0.306)	(0.302)	(0.304)	(0.307)	(0.310)
Controls	yes	yes	yes	yes	yes	yes
Village Fixed Effects	yes	yes	yes	yes	yes	yes
Age of marriage Fixed Effects	yes	yes	yes	yes	yes	yes
Wedding year Fixed Effects	yes	yes	yes	yes	yes	yes
R2	0.295	0.298	0.294	0.296	0.294	0.296
Number of observations	416	416	416	416	416	416

Notes: OLS regression. Sample of women. Robust standard errors in parentheses, clustered at the village level. *** 1%, ** 5%, * 10% significance. Constant not displayed. Rainfall is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls, as described in table 2, include dummies for mother and father highest level of education (no education, primary education and secondary/tertiary education), the principal component analysis for inadequate house and a dummy indicating urban areas. Source: Kagera Health Development Survey 1991-2010.

Table 10: Parameter estimates

Parameter	Estimate	Std. Error
b	0.392	0.014
δ	0.356	0.071
μ	14.883	0.032
σ^2	0.209	0.008
e	0.051	0.007
k_1	-44.991	4.365
k_2	45.060	3.757
k_3	4.456	1.058
k_4	-0.433	0.055
k_5	-0.079	0.013
k_6	0.008	0.001
k_7	-0.0002	0.00001

Table 11: Counterfactual consumption equivalence of age bans with and without credit markets

Panel A: Baseline has no credit market	
Counterfactual scenario	π
Minimum age of marriage is 16	-0.140%
Minimum age of marriage is 18	-0.175%
Panel B: Baseline has perfect credit market	
Counterfactual scenario	Π
Minimum age of marriage is 16	-0.029%
Minimum age of marriage is 18	-0.041%

Notes: Last column presents the share π of consumption that a household in the baseline scenario requires to be indifferent to counterfactual scenario. The equivalent variation π solves $\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}\frac{\left((1+\pi)c_{B,t}\right)^{1-b}}{1-b}+\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}m_{B,t}\cdot\xi_t=\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}\frac{c_{CF,t}^{1-b}}{1-b}+\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}m_{CF,t}\cdot\xi_t$.

Table 12: Counterfactual consumption equivalence – cash trasfer programs

	Individual transfer (Thousands of TZS)	Total cost per capita (Thousands of TZS)	π
Panel A: Reduces child marriage by 20%			
Conditional transfer	3.76	16.97	0.115%
Unconditional transfer	67.12	335.62	3.354%
Transfer to bottom 25% of income	74.76	93.95	0.884%
Panel B: Reduces child marriage by 50%			
Conditional transfer	10.65	50.25	0.407%
Unconditional transfer	209.78	1048.92	10.723%
Transfer to bottom 25% of income	227.12	285.42	2.783%
Panel C: Reduces child marriage by 100%			
Conditional transfer	35.11	175.39	1.604%
Unconditional transfer	880.74	4403.71	48.224%
Transfer to bottom 25% of income	880.74	1106.80	11.276%

Notes: Average annual income is 3243.41 thousands of Tanzanian shillings. Last column presents the share π of consumption that a household in the baseline scenario requires to be indifferent to the counterfactual scenario. The equivalent variation π solves $\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}\frac{\left((1+\pi)c_{B,t}\right)^{1-b}}{1-b}+\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}m_{B,t}\cdot\xi_t=\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}\frac{c_{CF,t}^{1-b}}{1-b}+\sum_{k=1}^{K}\sum_{t=14}^{T}\delta^{t-1}m_{CF,t}\cdot\xi_t$.

Appendix Figures and Tables

Figure A1: Variation in bride price amount, by cluster

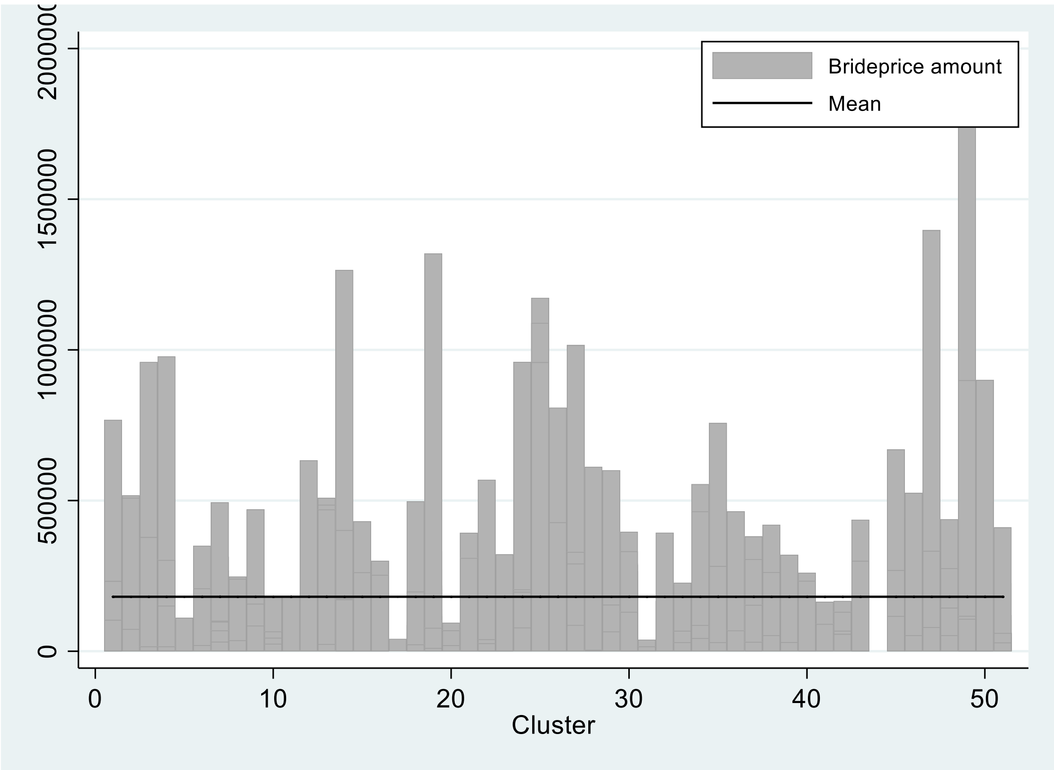


Table A1: Main reason for migration by gender

Panel A: Reason for migration		
	Females	*Males*
Marriage	63.64	9.76
Death of parents	6.06	9.76
Other family problems	6.06	9.15
Job	4.68	29.88
Schooling	2.48	2.44
Live healthier environment	1.93	0.61
Find land	1.38	11.59
Illness of HH member	1.10	0.6
Divorced	0.83	0.6
Life is better here	0.83	
Political/Economics problems	0.55	17.07
Widowhood	0.28	0.61
Following inheritage	0.28	7.32
Other	9.90	0.61
Observations	363	164

Panel B: T-test - Marriage is the reason for migrating	
	Migration for marriage
Marriage >18	0.303
Marriage <=18	0.436
p-value	0.000

Source: Kagera Health Development Survey 1991-2010.

Table A2: Early marriage and rainfall shocks in respondents' life cycle

	Females			Males		
Dependent variable:	*1 if married bw 15-18*	*1 if married bw 16-18*	*1 if married bw 17-18*	*1 if married bw 15-18*	*1 if married bw 16-18*	*1 if married bw 17-18*
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall shock. age 15-18	0.307***			-0.066		
	(0.098)			(0.055)		
Rainfall shock. age 19-22	-0.088			0.002		
	(0.086)			(0.060)		
Rainfall shock. age 16-18		0.187**			-0.054	
		(0.074)			(0.034)	
Rainfall shock. age 19-21		-0.025			0.013	
		(0.069)			(0.041)	
Rainfall shock. age 17-18			0.185***			-0.018
			(0.065)			(0.023)
Rainfall shock. age 19-20			-0.019			0.035
			(0.059)			(0.030)
Controls	yes	yes	yes	yes	yes	yes
Village Fixed Effects	yes	yes	yes	yes	yes	yes
Year of birth Fixed Effects	yes	yes	yes	yes	yes	yes
R2	0.163	0.148	0.150	0.223	0.229	0.269
Number of observations	591	599	575	375	378	378

Notes: OLS regressions. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5%, * 10% significance. Constant not displayed. Rainfall is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls, as described in table 2, include dummies for mother and father highest level of education (no education, primary education and secondary/tertiary education), the principal component analysis for inadequate house and a dummy indicating urban areas. Source: Kagera Health Development Survey 1991-2010.

Table A3: Probability of marriage by age 13-16

	Females					Males	
Dependent variable	*1 if married bw 13-14*			*1 if married bw 14-15*		*1 if married bw 14-15*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rainfall shock. age 15-18	-0.020						
	(0.032)						
Rainfall shock. age 16-18		-0.015		0.028		0.002	
		(0.019)		(0.042)		(0.003)	
Rainfall shock. age 17-18			-0.019		0.003		-0.003
			(0.020)		(0.030)		(0.004)
Controls	yes	yes	yes			yes	yes
Village Fixed Effects	yes	yes	yes			yes	yes
Year of birth Fixed Effects	yes	yes	yes			yes	yes
R2	0.177	0.177	0.177	0.133	0.132	0.185	0.186
Observations	674	674	674	674	674	395	395

Notes: OLS regressions. Robust standard errors in parentheses, clustered at the village level. *** 1%, ** 5% , * 10% significance. Constant not displayed. Rainfall is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls. as described in table 2, include dummies for mother and father highest level of education (no education, primary education and secondary/tertiary education), a dummy for respondents living in inadequate house, a dummy indicating urban areas. Source: Kagera Health Development Survey.

Table A4: Probability of marriage at age 19-24

	Females			Males		
Dependent variable:	*1 if married bw 19-20*	*1 if married bw 21-22*	*1 if married bw 23-24*	*1 if married bw 19-20*	*1 if married bw 21-22*	*1 if married bw 23-24*
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall shock. age 17-18	-0.002			0.006		
	(0.050)			(0.050)		
Rainfall shock. age 19-20	-0.036			0.030		
	(0.055)			(0.060)		
Rainfall shock. age 16-18		-0.124			0.118	
		(0.077)			(0.082)	
Rainfall shock. age 19-21		0.043			-0.020	
		(0.063)			(0.119)	
Rainfall shock. age 15-18			-0.060			-0.087
			(0.050)			(0.121)
Rainfall shock. age 19-22			0.030			-0.080
			(0.049)			(0.157)
Controls	yes	yes	yes	yes	yes	yes
Village Fixed Effects	yes	yes	yes	yes	yes	yes
Year of birth Fixed Effects	yes	yes	yes	yes	yes	yes
R2	0.148	0.103	0.151	0.259	0.195	0.196
Number of observations	649	634	614	377	381	384

Notes: OLS regressions. Robust standard errors in parentheses, clustered at the village level. *** 1%, ** 5%, * 10% significance. Constant not displayed. Rainfall is the absolute value of rainfall deviation (in millimeters) from the rainfall historical mean in each cluster from 1981 to 2010 in the six months of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls, as described in table 2, include dummies for mother and father highest level of education (no education. primary education and secondary/tertiary education), a dummy for respondents living in inadequate house, a dummy indicating urban areas. Source: Kagera Health Development Survey.