Selling daughters: age at marriage, income shocks and bride price tradition*

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PRELIMINARY AND INCOMPLETE

Abstract

Cultural and social norms may play a role in supporting economic development, but they can also reduce the wellbeing of some groups. In this paper, we explore how the practice of bride price – a transfer made by the groom to the bride's family at marriage – increases the probability of adolescent and child marriages. We develop a simple dynamic model with incomplete markets in which households have a higher probability of marrying their daughter early when hit by an adverse income shocks. To estimate the causal effects of income shocks on early marriages, we exploit exogenous variation in rainfall shocks over a woman's life cycle. Using a 19-years panel dataset from Tanzania, we find that adverse shocks increase the probability of teenage marriages. This is particularly true in the subsample of respondents who report a bride price payment at marriage. Finally, numerical simulations of our theoretical model show that improving access to credit markets could substantially delay the age at marriage.

1 Introduction

Adolescent and child marriage is still a common practice in many countries, especially among girls. One third of women aged 20-24 years were married before turning 18 worldwide in 2013.

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This phenomenon is particularly widespread in the poorest regions: 40% of women aged 20 to 24 years were child bride in sub-saharan Africa, compared, for example to 10% in eastern and central Europe (UNICEF, 2014). A direct consequence of early marriages is adolescent fertility. In Tanzania, the setting of our study, 22.8% of girls aged 15 to 19 had children or were pregnant in 2010, while the adolescent fertility rate (the number of births per 1,000 girls aged 15-19) was 126, giving Tanzania the highest adolescent fertility rate in the world (World Development Indicator, 2014).[1] The relationship between female early marriage, early fertility and poor physical and socio-economic outcomes is now well established in the literature. Teenage marriages are associated with girls' lower educational attainment, lower use of preventive health care services, less bargaining power within the household, more physical abuse and domestic violence (Jensen and Thornton, 2003; Field and Ambrus, 2008). Despite this evidence, little research has examined the important question of why such a practice is still so widespread in many countries. Understanding what lies underneath adolescent and child marriages is crucial to improve women's socio economic outcomes, reduce gender wage gap and ultimately promote economic development (Duflo, 2005; Doepke, Tertilt and Voena, 2012).

The goal of this paper is to explore the relationship between the probability of early marriages and one specific social norm, namely the bride price payment. Bride price is defined as a transfer from the groom to the family of the bride to purchase the rights to her labor and reproductive ability and is prevalent in many part of the world, including most sub-Saharan Africa countries and many parts of Asia (Anderson, 2007*a*). Although bride price varies substantially across cultures and countries, it can constitute a sizable transfer to the bride's household. Young girls are hence a potentially important asset for their family since they can be given in marriage in exchange for a bride price. Households, hit by negative income shocks and with little access to credit market, may therefore "sell" their girls before reaching adulthood, thus excerbating the practice of early marriages.

With this in mind, we examine the following questions:

(i) are households more likely to marry off their daughters earlier when hit by adverse income shocks?;

[1] For comparison, adolescent fertility rates in 2010 were equal to 26 in United Kingdom, 5 in Italy and 3 in Switzerland (The World Bank, 2014).

(ii) could the relationship between income shocks and age at marriage be explained by the presence of the bride price custom?
(iii) could well-functioning credit markets overcome the impact of the bride price tradition and thus reduce the probability of child marriages?

To answer to these questions, we first develop a simple life-cycle model in which households are exposed to income shocks and have no access to credit markets. Upon the marriage of their daughter, parents obtain a bride price payment, which depends on her age. Hence, in the absence of income uncertainty, there exists an optimal age at which parents want to marry their daughters. We show instead that, right after a negative income shock, parents may decide to marry off their daughter sooner than what would happen in the absence of income uncertainty.

The prediction of the model is tested using a 19-years panel dataset from Kagera, Tanzania - the Kagera Health Development Survey 1991-2010 (KHDS) - and weather data from the NASA Langley Research Center. In particular, we exploit exogenous variation in rainfall shocks to study the causal effects of income shocks, a proxy for the need of a bride price transfer, on the age of marriage. This identification strategy allows us to address the endogeneity that would be otherwise present when analyzing the direct effect of the social norm on individual outcomes since unobserved individual characteristics, such as physical appearance and ability, may simultaneously influence the amount of the bride price paid and the age at marriage. Our hypothesis is that daughters can be "sold" to a groom when the household is hit by a negative income shock, in particular when the household has little access to credit markets. After controlling for village and cohort fixed effects, we find that girls hit by a rainfall shock at the age of 18 have a higher probability of being married before 18, while negative income shocks after that age do not have any statistically significant effect on the likelihood of teenage marriages. Interestingly, rainfall shocks early in life are not associated with early marriages for boys. These different estimates for girls and boys suggest the presence of a custom that mainly matters for adverse income shocks for the girls but not for boys, such as the bride price. In the paper, we conduct a number of tests to validate this interpretation.

Finally, we perform some preliminary numerical simulations of our model, calibrated using data on income and bride price amounts available in the KHDS. The patterns of age at marriage in these simulations track the empirical ones remarkably well under the assumption of no credit markets, a typical features of developing countries. Relaxing that assumption by granting access to credit markets substantially delays the age at marriage.

Our paper fits into the broad literature in economics investigating the importance of cultural norms - behaviors that are enforced through social sanctions - on economic development. Previous works have examined the implications of descent rules on different economic outcomes. Ferrara (2007) tests the implication of the matrilineal inheritance rule in Ghana, where the largest ethnic group (Akan) is traditionally matrilineal, on inter-vivos transfer. She finds that children respond to the threat of disinheritance, due to the enforcement of the matrilineal rule, by increasing transfers to their parents during lifetime to induce a donation of land before the matrilineal inheritance is enforced. In a companion paper, Ferrara and Milazzo (2012) investigate the effects of the matrilineal inheritance rule on children's human capital accumulation. Using data from Western Ghana, Quisumbing et al. (2001) explore the impact of matrilineal land tenure institutions on women's rights and the efficiency of cocoa tree resource management.

A strand of this literature has focused on the role of marriage practices (e.g., polygyny and patrilocal norms) and marriage payments (dowry and bride price) on development (Jacoby, 1995; Gaspart and Platteau, 2010; Botticini and Siow, 2003; Ashraf et al., 2014; Bau, 2012). The latter is a particular worthwhile topic to study because they are consistent intergenerational transfers of wealth. These transfers of wealth affect households' saving behavior and wealth accumulation (Botticini, 1999). Tertilt (2005) and Tertilt (2006) study the relationship between polygyny, often associated with bride price, and different socio-economic outcomes, such as higher fertility, bigger spousal age gap and lower investment in daughters. In a recent paper, Ashraf et al. (2014) show a surprising economic consequence of the bride price. By exploiting two school construction programs in Indonesia and Zambia, they found that ethnic groups that traditionally engage in bride price payments at marriage increased female enrollment in response to the program. Within these ethnic groups, higher female education at marriage is associated with a higher bride price payment received, providing a greater incentive for parents to invest in girls' education. They suggest that any change to the cultural custom of bride price should likely be considered alongside additional policies to promote female education.

The remainder of the paper is organized as follows. In section 2, we describe the tradition of marriage payment, 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 describes the data and shows some descriptive statistics. In section 5, we describe the identification strategy and in section 6 we show our main results. Section 7 reports the results of the numerical policy simulations of the model under different assumptions about the credit markets. Section 8 concludes.

2 Child marriages and bride price payments

Agreement on spouses' resources is a crucial element in the marriage culture of many developing countries. The most well-known type of marriage payments are bride prices and dowries. 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. Paying a bride price is an ancient tradition practiced throughout Africa. In the southern regions it is known as lobola and in East Africa as *mahari*. On the contrary, dowry payments involve a transfer from the bride to the family of the groom upon the marriage.

Many hypotheses have attempt to explain the occurrence of bride price and dowry. In his seminal work, Becker (1981) explains the existence of dowry and bride price as tools to clear the marriage market. When grooms are scarce (e.g., in monogamous and virilocal societies), brides pay dowries to grooms; when women are scarce (e.g., in polygamous societies) grooms pay bride price to brides. Another hypothesis links marriage payments to the economic value of women. Bride price customs exist in cultures where women make valuable contributions to agricultural work or other economic activity in the household (Boserup, 1970; Giuliano, 2014). In regions where women do not make any contribution, women constitute an economic liability and hence pay a dowry at the time of marriage. A third hypothesis links marriage payments to the rights of inheritance held by women and explains dowry as a premortem bequest made to daughters (Maitra, 2007).

Historically, the bride price custom has been more common than that of dowry. Less than 4 percent of the cultures listed in Murdock's Ethnographic Atlas (1967) have dowry payments, whereas two-thirds follow a norm of bride price (Anderson, 2007*b*). However, dowry payment has played a more significant role, because they has occurred mainly in Europe and Asia, where more than 70 percent of the world's population resides. Although the custom of dowries has disappeared in most of the western region, it remains widespread in South Asia. Bride prices have prevailed extensively and are still very common in Africa, South and East Asia (Maitra, 2007). In the data from Tanzania we are using in this study, bride price was paid in 81% of marriages, with an average amount of 133,280 Tanzanian Shilling (about 77 USD) and a maximum amount of 1,005,000 (about 581 USD). Tanzanian law governing marriages allows for bride price payments.

A lively public debate is currently ongoing in Africa on the adverse consequences of the bride price custom (see among others (Kizito, 2013), (Mtui, 2013)). It is argued that this practice increases the incentive for parents to "sell" their girls for receiving a bride price and decrease the probability for married women to end a marriage because their parents have to return the bride price back. In a recent interview of the Thomson Reuters Foundation conducted in a village in Bagamoyo, Tanzania, a 15 years 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 fulfil it as I got married and became pregnant. Now I have a child it's unlikely I would go back to school" (Kizito, 2013).

Although anecdotal evidence show a relationship between brideprice custom and child marriages, so far no rigorous evidence of this association has been provided.

3 Model

In this section, we develop a simple dynamic model with incomplete markets in which households are exposed to i.i.d shocks to their income y_t, distributed as $logN(\mu, \sigma^2)$, and cannot borrow nor save. Parents have a daughter and obtain a bride price payment upon her marriage. The bride price BP_t is a function of the daughter's age.

Households live till time T. They have utility $ln(c_t)$ over consumption in each period. In each period, they choose consumption c_t. If their daughter is unmarried ($M_t = 0$), they choose whether or not to give her in marriage in that period $m \in \{0, 1\}$, which will result in $M_{t+1} = 1$.

Hence, they solve the following problem:

$$max_{c\geq 0, m\in\{0,1\}} \qquad \sum_{t=0}^{T} \beta^t E_0[ln(c_t)]$$

$$\begin{aligned}
&s.t. \quad c_t \leq y_t + BP_t \cdot m_t \\
&\text{if } \ M_t \text{ then } m_t = 0 \qquad\qquad \forall \text{ period } t \text{ and state of nature } s^t \\
&\text{if } M_t = 0 \ \text{ then } \ m_t \in \{0,1\} \\
&\text{if } m_t = 1 \ \text{ then } \ M_{t+1} = 1 \\
&M_0 = 0.
\end{aligned}$$

The problem admits the following recursive formulation:

$$V_t(M_t) = max_{c_t\geq 0, m_t\in\{0,1\}} \qquad ln(c_t) + \beta E_t[V_{t+1}(M_{t+1})]$$

$$\begin{aligned}
&s.t. \quad c_t \leq y_t + BP_t \cdot m_t \\
&\text{if } \ M_t = 1 \text{ then } m_t = 0 \\
&\text{if } M_t = 0 \ \text{ then } \ m_t \in \{0,1\} \\
&\text{if } m_t = 1 \ \text{ then } \ M_{t+1} = 1 \\
&M_0 = 0
\end{aligned}$$

The household problem can be solved backwards. In the last period, if the daughter is not yet married ($M_T = 0$), the household will have her marry and will consume all the cash on hand:

$$c_T = y_T + BP_T.$$

If the daughter is already married ($M_T = 1$), then $c_T = y_T$.

This decision process will lead to a terminal value $V_T(M_T) = ln(c_T)$. In every other period, conditional on a m_t choice, $c_t = y_t + BP_t \cdot m_t$. The value of marrying at time t is equal to:

$$V_t(M_t = 0, m_t = 1) = ln(y_t + BP_t) + \beta E_t[V_{t+1}(M_{t+1} = 1)]$$

The value of waiting to marry at time t is equal to:

$$V_t(M_t = 0, m_t = 0) = ln(y_t) + \beta E_t[V_{t+1}(M_{t+1} = 0)]$$

where $E_t[V_{t+1}(M_{t+1} = 0)] = E_t[max\{V_{t+1}(M_{t+1} = 0, m_{t+1} = 1)], V_{t+1}(M_{t+1} = 0, m_{t+1} = 0)\}]$ and

$$E_t[V_{t+1}(M_{t+1} = 0)] > E_t[V_{t+1}(M_{t+1} = 1)].$$

Hence, when $M_t = 0$, parents decide to marry off their daughter, $m_t = 1$, if and only if

$$ln(y_t + BP_t) - ln(y_t) + \beta\{E_t[V_{t+1}(M_{t+1} = 1)] - E_t[V_{t+1}(M_{t+1} = 0)]\} > 0. \tag{1}$$

We examine the relationship between the realization of income in a given period (y_t) and the marriage probability over the life cycle.

Proposition 1. *A low realization of income at time t increases the probability that the daughter marries in period t, if she is not yet married.*

Proof. Based on equation 1, the probability that the daughter will marry at time t, given the random distribution of shocks y_t, is then:

$$\begin{aligned} &P\Big(m_t = 1 | M_t = 0\Big) \\ &= P\Big(ln(y_t + BP_t) - ln(y_t) + \beta\{E_t[V_{t+1}(M_{t+1} = 1)] - E_t[V_{t+1}(M_{t+1} = 0)]\} > 0\Big) \end{aligned}$$

which is decreasing in y_t if $BP_t > 0$. This is because the continuation values $V_{t+1}(\ )$ do not depend on y_t, in the absence of credit markets, and because $\frac{\partial[ln(y_t+BP_t)-ln(y_t)]}{\partial y_t} = \frac{1}{y_t+BP_t} - \frac{1}{y_t} < 0$ as long as $BP_t > 0$. □

The proposition tells us that if a household is hit by an adverse income shock in a given period, the probability that the daughter will marry in that same period increases. In the absence of credit markets, we do not expect past shock to matter for future marriage probabilities.

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

4 Data and descriptive statistics

We describe below the sources of data we used in our empirical analysis and in the micro-simulations.

Kagera Health Development Survey, 1991-2010. The main dataset come from 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 11.885 are covered by the waters of Lake Victoria. The KHDS involved 6 rounds of data collections between 1991 and 2010, then creating a 19-years panel dataset. The survey interviewed 6,353 individuals living in 51 villages (also referred to as 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 was residing in a new household. Excluding those who died, 85% of all the respondents surveyed during the baseline were re-interviewed in 2010.[2]

Several features makes this dataset particularly appropriate for studying the effect of the bride price on marital outcomes. First, the last wave of the survey contains detailed retrospective information on marriage, including the date of marriage, the characteristics of the marriage (i.e. formal or informal) as well as all the cash and in-kind transfer from the groom's family to the bride's family and viceversa. [3]Second, a fairly high share of the married respondents report that payments were made at the time of their marriage, giving us the opportunity to study the effect of the bride price custom on outcomes.

Our final sample includes 1,161 individuals, aged 18-46, born between 1966 and 1988 with non-missing information on the age of marriage and on weather shocks.

[Insert figure 1]

[2]For additional infomation on the KHDS see (Weerdt et al., 2012).

[3]The year of marriage was not recorded for some respondents by mistake during the data collection. To correct this flaw, respondents with missing information were re-contact through telephone interviews.

Figure 1 shows the distribution of ages at marriages for the men and women in the sample. The average age at marriage for women is nearly 21 years with a minimum value of 7 years, while the average age at marriage for the males is 24 years, with a minimum value of 6 years. A sizable portion of women marry in their teenage years, while typically fewer men do so.

[Insert table 1]

In Tanzania, the legal minimum age of marriage for boys is 18, while girls are legally eligible to marry at 15. However, either sex 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)). Table 1 shows summary statistics for the main variables of interest and the controls in our sample. Approximately 4% of the respondents got married before the age of 15 and nearly 20% of the sample reported an age at marriage below 18 years. A large share of married individuals (81%) reported that a bride price payment was made at the time of marriage, with an average amount of bride price payment in the sample is 98,862 Tanzanian Shilling (about 55.5 USD) and a maximum amount of 997,842 (about 560 USD), 44 (Panel A). [4] Looking at socio-demographic characteristics (Panel B), we note that more than half of the sample are women and only 16% of the respondents live in urban areas. Approximately 87% (72%) of the respondents have a mother (father) with primary education and only 0.1% (0.7%) of them report a mother (father) with a university degree. 20% of the respondents live in inadequate houses, with floor, outside walls and roof made by made by mud, bamboo tree or earth. The average food and total consumption per capita in the past 12 months is equal to 347,880 Tzs (about 201 USD) and 196,611 Tzs (about 114 USD), respectively. Food and total consumption are used in natural logarithm in the empirical analysis.

Rainfall data 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

[4] The bride price amount in cash has been deflated using the Consumer Price Index (CPI) in the year of wedding with 2010 as a base year. Respondents were asked to report the corresponding value in Tanzanian Shelling of bride prices paid in-kind or in livestock (44% of the total bride price amount).

higher(Organization, 2013). Kagera region is not an exception. In our sample, 83% of the respondents do mention agriculture as one of the main activity 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 and variations in rainfall may result in a large variation in income and consumption for Tanzanian households. Especially given its bordering with the Lake Victoria, Africa's largest lake, natural hazards include both flooding and drought. We then use the Modern-Era Retrospective analysis for Research and Applications (MERRA) database at the NASA Langley Research Center on daily rainfall estimates as a source of exogenous variation for income shocks.[5] MERRA is a global gridded data set based on retrospective analysis of historical weather data obtained from satellite images and weather stations. The dataset provides daily precipitation (in mm) aggregated into grids that are $1/2°$ in latitudes $* 2/3°$ in longitude (roughly 55 km $*$ 75 km at the equator). Daily precipitation from 1981 to 2010 are linked to our 51 baseline villages (or cluster) through GPS coordinates.

For each village, we compute the historical mean level of annual precipitations (in millimeters) during the growing season (March, April, May and October, November, December) between 1981 and 2010.[6] As shown in panel C, table 1, the historical annual mean level of precipitation from during the growing seasons is about 895 millimeters per year. For each cluster and for each year, we then compute rainfall deviations (in millimetres) from the rainfall historical mean. Our measures of rainfall shocks, called $RainfallAtAge\ a_{i,v,y}$ is the absolute value of rainfall deviation from the historical mean for the individual i, in village v, born in year y, at a particular age a. For example, the variable "Rainfall, age 18" in panel C in table 1 indicates the difference (in absolute value) between the yearly millimetres of rainfall during the growing season 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 season. Similarly, we compute measures of rainfall shocks within some age ranges: 15-18, 16-18, 19-20, 19-21.

[Insert table 2]

[5] The use of weather variations as proxy for income shocks is not new in the economic literature. See Miguel, Satyanath and Sergenti (2004); Nyqvist (2013); Dustmann, Fasani and Speciale (2015), among others.

[6] Northern Tanzania has a long rainy season (Masika) from March to May and a short rainy season (Vuli) from October to December. 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 in January/February (*(of Agriculture, 2003)*).

In table 2, we test the relationship between weather shocks and consumption. Specifically, we run OLS regressions using the KHDS panel dataset from 1991 to 2010, of the logarithm of total yearly aggregate consumption per capita (columns 1-5) and food consumption per capita (columns 6-10) on the absolute values of rainfall deviation from the historical mean, including year and cluster fixed effects. Results show that the rainfall shocks are negatively correlated with the measure of consumption in our data at $t-1$. The coefficient on rainfall in the previous year is statistically significant at 1% level in all the specifications and it seems therefore a reliable measure of income shocks. At first glance, the non-statistically significant coefficient on rainfall shock in the current period is surprising. However, notice that rainfall shocks have been computed in the two growing seasons in Kagera, March-May and October-December, while the survey questions on consumption in the last 12 months have been asked through out the full year. Hence, it may be plausible that household were not yet hit by the adverse shocks while answering those question during the KHDS. In columns 4-9 of table 2, we include in the regression the current, the previous and the shocks in the following year and show a statistically significant correlation only between weather shock in the previous year and consumption. 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[7]) but these measures are not as strongly correlated with consumption as the ones we used.

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 age of marriage. For this reason, we exploit exogenous variation in weather

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

shocks across villages in Tanzania to study the causal effects of income shocks, a plausible proxy for the need of a bride price transfer, on the probability to marry before 18 years old. Specifically, we estimate the following linear probability model:

$$Y_{i,v,y} = \alpha + \sum_{a} \beta_a Rainfall\,At\,Age\,a_{i,v,y} + \lambda X_{_{i,v,y}} + \delta_v + \gamma_y + \epsilon_{i,v,y} \qquad (2)$$

where $Y_{i,v,y}$ takes value 1 if individual i, in village v, born in year y, got married before the age of 18, and 0 otherwise. $Rainfall\,At\,Age\,a_{i,v,y}$ 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 the mother and the father; a dummy equal to one if the respondent lives in urban area, 16 dummies indicating the ethnic group of the head of household and a dummy for an unadequate type of dwelling.[8] 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. A positive value of one of these coefficients indicates that adverse income shocks positively influence the probability of early marriage.

We estimate equation (2) using OLS with standard errors clustered at the village level. We report results for the sample of married individuals, separately for women and men.

[Insert figure 2]

Figure 2 shows a considerable variation in rainfall shocks across villages of residence and year of birth.

Next, to investigate whether age of marriages is related to the bride price, we estimate equation (2) for the subsample of respondents that declare a bride price payment at the time of their marriage.

[8]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.

6 Results

[Insert Tables 3 and 4]

Table 3 reports the estimated coefficients for equation (2) for the sample of females. In column 1, we start by including the averse rainfall shocks one year before, one year after and during respondent's 18 years. Results show that being exposed to a rainfall shock by the age of 18 years ($Rainfall\,At\,Age\,18$) increases the probability of child marriage. On the other hand, being exposed to a shock after 18 years does not have any statistically significant effect on the dependent variable. On average, (across villages) a one standard deviation in the rainfall shock at age 18 is associated with 9.8 percentage points higher probability of early marriage. In column 2, we add controls for rainfall shocks at age 16 and 20. Results shows that individuals exposed to negative income shocks at 17 or 18 years have a higher probability of marriage before or at that age, suggesting that current and previous shocks are a good predictors for early marriages. It is interesting to note that the coefficients on rainfall shocks before 18 are all positive and their size monotonically increases as we move towards the threshold of 18 years, while after the threshold, the coefficients on shocks are of the opposite sign. In column 3, we show that these findings hold also when controlling for shocks three years before and after the 18 years threshold. In columns 4 and 5, we aggregate the rainfall shocks by taking their averages two and three years before and after the 18 years threshold. Results are striking: being exposed to adverse rainfall shocks between 16 to 18 years old increases the probability of child marriages, while the latter is not influenced by shocks happened between 19-20 years. Similarly, respondents who were exposed to rainfall shocks between 15 to 18 of age are more likely to be married by the age of 18 (column 5). In term of magnitude, on average one standard deviation increase in rainfall shocks between 15-18 increases the probability of marriage before 18 by 10 percentage points. Among the other controls, it is interesting to note the coefficients on mother secondary and tertiary education is negatively and statistically significant correlated with the probability of child marriages. Tables A1 and A2 in the appendix report estimated coefficients for equation (2) using the age of marriages as dependent variable. Results are very similar to the ones shown in tables 3 and 4 above.

In table 4, we show the results for the sample of males. Almost all the coefficients on rainfall shocks are negative but not statistically significant, with the exception of the coefficient on rainfall at age 17 in column 1. Our main takeaway from tables 3 and 4 is therefore that negative income shocks during and before 18 years old led to an increase in the probability of marriages before 18 for girls but not for boys. A potential interpretation of the above findings in that households hit by adverse income shocks are more likely to marry off their daughters to receive a bride price transfer from her future groom. An alternative interpretation of the above findings could be that rainfall shocks increase early marriages because households wants to give away the less productive members and in some household, this may meaning marry off girls. While a rigorous analysis of the endogenous choice of the bride price on age of marriage is not possible with the data at hand, in what follow, we try to rule out some competing explanations and gather some evidence to validate the proposed interpretation.

[Insert Table 5]

In table 5, we augmented our main equation (2) with the interactions between the rainfall shocks and dummies denoting if, at the time of the shock, the respondent was the eldest girl in the household. What we expect is that the relationship between rainfall shocks and age of marriage is stronger for older girls. If the bride price idea is valid, households are probably more prone to marry off older girls first. To identify the eldest girls in the household, we consider the entire household structure at the time of the shock and we focus on the eldest girl (excluding the spouses and heads of households). For example, the variable *Eldest, age 15* is equal to one if the respondent was the eldest girl in the household (or the only one) when she was 15 and 0 if she was not the eldest or if he was a boy. Results in columns 1-3 show that being the eldest girl at 18 years old and being exposed to an income shocks at that same age increases the probability of child marriages. Given that young and old daughters should have the same weight on an household's income and, this latter finding points out in the direction that the effect of income shocks on child marriages may be due to the bride price custom.

[Insert Tables 6 and 7]

The last two waves of the KHDS include one question that allows us to verify the plausibility of the bride price interpretation. The questions asks to married respondents 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, grandparent and how much was it worth. In table 6, we report estimated coefficients for equation (2) for females, by splitting the sample between individuals who declare in the survey that a bride price was paid at marriage (columns 1-5) or not (columns 6-10). The coefficient on rainfall shocks at age 18 remains statistically significant (at 1 percent level) only in the subsample of women who received a bride price payment upon their marriage. When looking at the sample of men (table 6), we note that none of the shocks influence the probability of child marriages both in the sample of men declaring a bride price or not. Although the choice of bride price is endogenous to early marriages, these simple correlations seem to point in the direction of interpreting the bride price as a source of insurance for income shocks in the presence of credit constraint.

7 Policy micro-simulations

In this section, we perform some numerical simulations of the model described in section 3 to assess the extent to which such a simple model can replicate the patterns observed in the data and to evaluate the impact of policies that allow households to borrow and save on the distribution of age at marriage.

[Insert figure 3]

The first step is to choose the parameters of the model to perform these simulations. We calibrate BP_t to match the profile of bride price payments over the women's age at marriage in the KHDS data, conditional on educational attainment, as shown in figure 3. Because of the small number of observations available, we focus on the group of women who completed primary education only, which is the largest educational group. We also restrict marriage to occur between age 14 and age 26, to match the data, since very few marriages occur outside of this window for this educational group.

This is clearly an important simplification: we are assuming that bride price amount is uniquely determined by a woman's age and education, and not by other unobserved characteristics.[9] The presence of unobserved characteristics related to the age at marriage would bias our estimates of the relationship between bride price amounts and the daughter's age. In future work, we will relax this assumption and estimate the distribution of daughter's unobservable characteristics from the data to match the regression results described in section 6.

[Insert figure 4]

We then use data on agricultural output to calibrate the income process over the life cycle. We set the discount factor β to 0.98, as common in the literature. We perform 20 simulations of 682-households random samples (like in the KHDS data) of the above model by drawing income shocks over the life cycle.

Calibrated parameters

Parameter	
Discount factor (β)	0.98
Variance of log-income shocks (σ^2)	0.8
Interest rate (r)	12%

First, we compute the fraction of daughters married by age, hence the fraction of women for which $M_t = 1$. In these simulations, 29.1% of girls are married by age 18. We compare that number to the fraction of girls with primary education married by age 18 in the KHDS data, conditioning on marrying between age 14 and age 26, which is equal to 32.7% (figure 4).

We then simulate a simple counterfactual case, in which households have access to perfect credit markets. This simply implies that the parents' problem is modified in the following way:

$$\begin{aligned} max_{c\geq 0, A, m\in\{0,1\}} \quad & \sum_{t=0}^{T} \beta^t E_0[ln(c_t)] \\ s.t. \quad & c_t + A_{t+1} \leq y_t + BP_t \cdot m_t + (1+r)A_t \\ & A_{T+1} \geq 0 \\ & m_t = 0 \text{ if } M_t = 1 \\ & M_{t+1} = 1 \text{ if } (M_t = 1 \text{ or } m_t = 1) \\ & M_0 = 0. \end{aligned}$$

[9] The link between bride price amounts and educational attainment of the bride has been documented by Ashraf et al. (2014) in both Indonesia and Zambia.

We calibrate the interest rate r to be equal to 12%.

In the case of perfect credit markets, daughters get married when the bride price is highest, or close to highest, given the cost of borrowing. Hence, in this extreme case no girls will marry before age 18, while all will marry between age 23 and age 24.

As an additional numerical exercise, we replicate the empirical analysis that we had performed on the KHDS data using the simulated data. Under the assumption of no access to credit markets, we find that one standard deviation change in household income when the daughter is 17 years old is associated with a 4.1 percentage points increase in her probability of being married by age 18. Similarly, if the shock is experienced at age 18, the probability of being married by the end of that year increase by 6.6 percentage points. When credit markets are perfect, in these simulations, we find no correlation between current income shocks and the timing of marriage before age 23.

8 Conclusions

In this paper, we shed light on one important reason why child marriages are still a widespread practice in many developing countries, despite the adverse consequences for women socio-economic status (e.g., lower educational attainment, domestic violence, etc.). We show, theoretically and empirically, that the traditional social norm of bride price – a transfer from the groom to the bride's family at marriage – can be an important tool, in the absence of well-functioning credit markets, to insure households against negative income shocks. Households who are exposed to adverse income shocks have a higher probability of marrying their daughters earlier than in the absence of income uncertainty, in exchange for a bride price payment.

Our results can be important for policy makers in poor countries, where access to credit is severely limited, to reduce girls early marriages and promote women's empowerment. A natural extension to this type of research would be to conduct a randomized control trial to test whether a weather insurance scheme may allow households to delay their girls' marriages, by relaxing liquidity constraints. We will then be possible to more rigorously investigate whether the presence of a well-functioning credit market can overcome social norms, such as the bride price custom.

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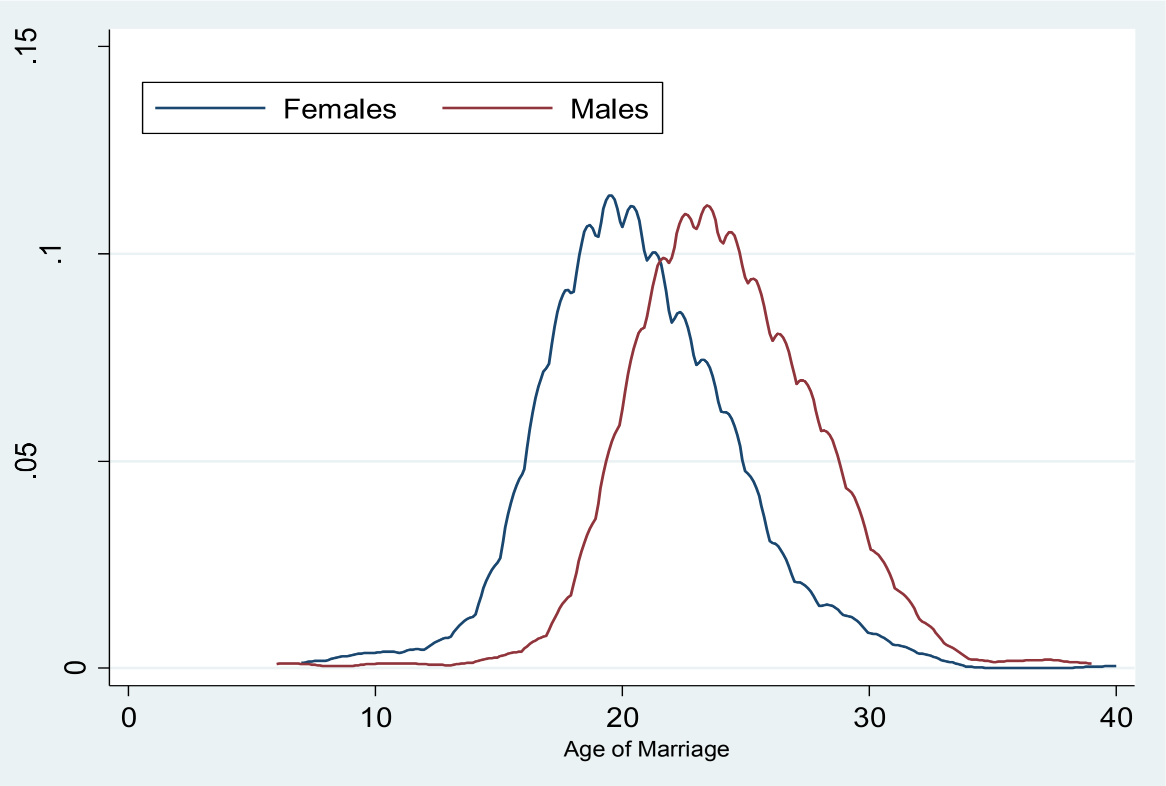
Figures and Tables

Figure 1: Age of marriage, by gender



Notes: Sample of respondents with non-missing value for the age of marriage. Kernel density of distribution of ages at marriages in Kagera (Tanzania). Source: Kagera Health Development Survey, 1991-2010

Figure 2: Rainfall variation at age of 18 by cluster and year of birth

Notes: Sample of respondents with non-missing value for the age of marriage. The figure shows the variation in the rainfall shock within cluster and year of birth. On the horizontal axis, we report the year of birth and on the vertical axis, we report the absolute value of rainfall deviation (in millimetres) from the rainfall historical mean in each cluster from 1981 to 2010 in the six month of the growing seasons (March, April, May and October, November, December) for respondents at age 18. Source: Kagera Health Development Survey, 1991-2010 for the year of birth and NASA Langley Research Centre for data on precipitation in Kagera.

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

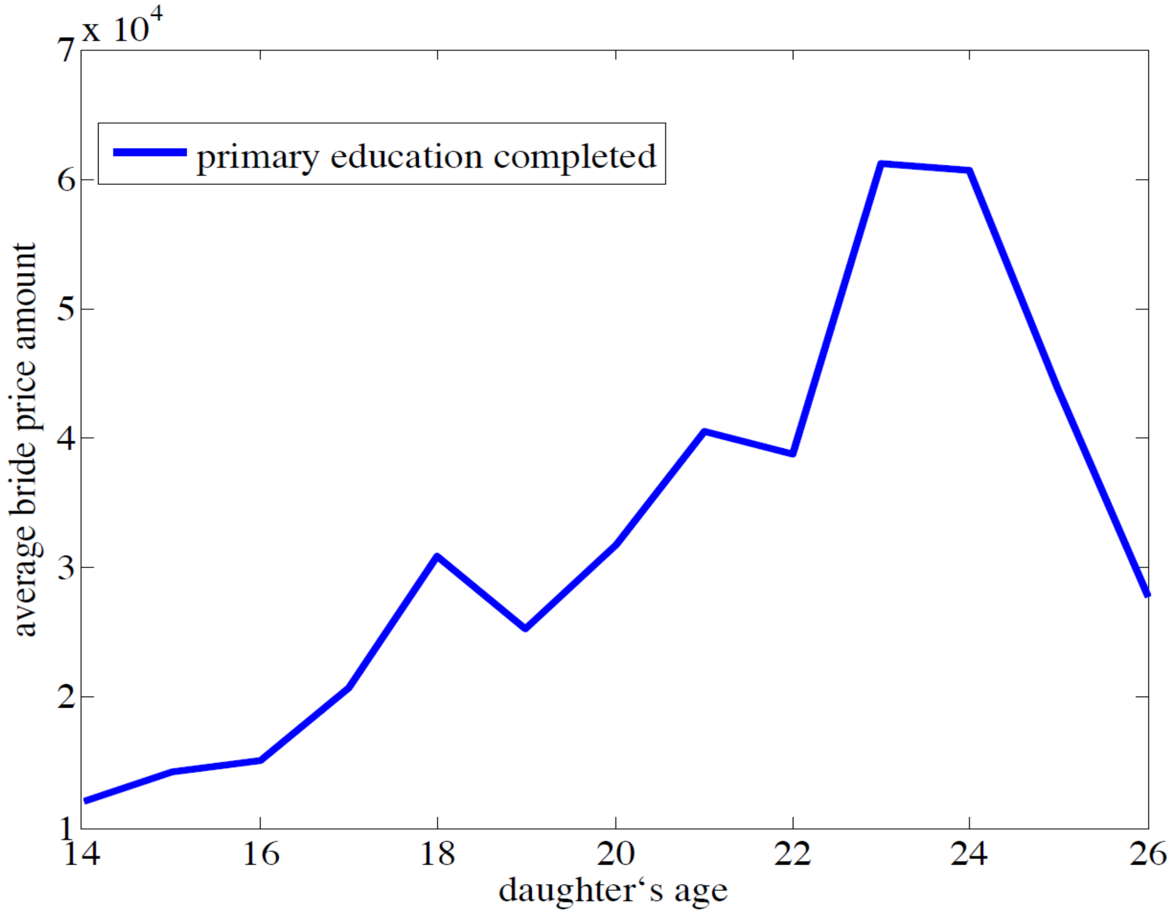


Figure 4: Distribution of ages at marriage in the data and in the simulation

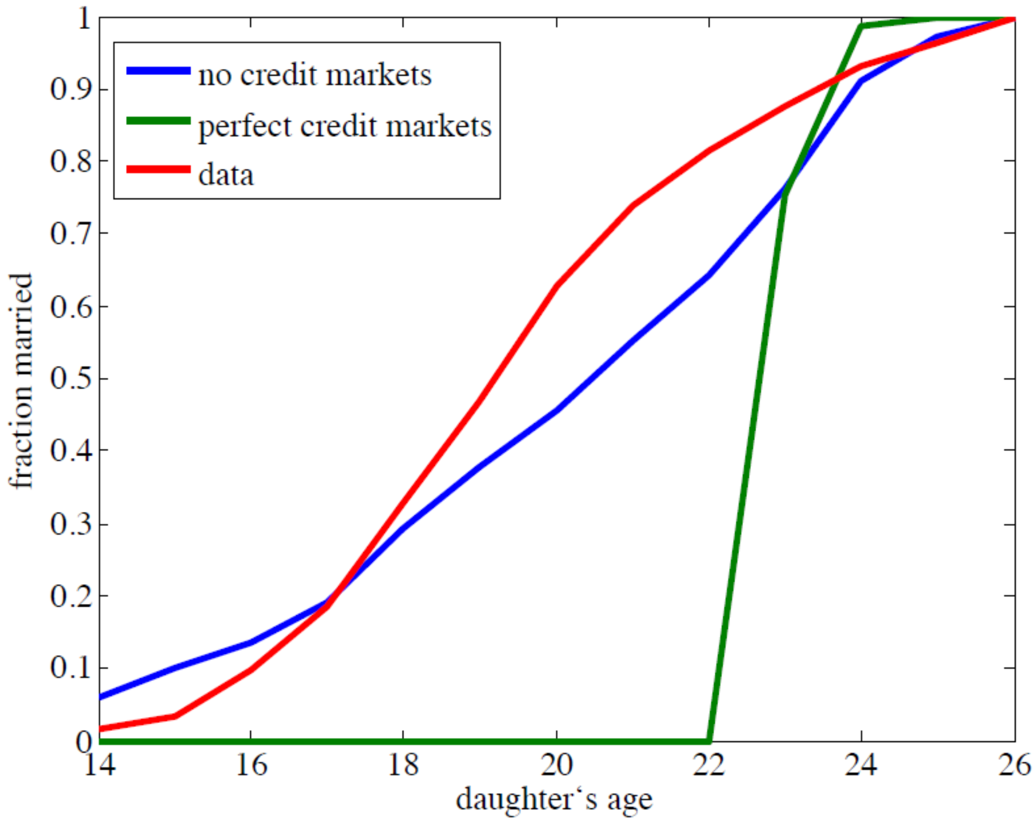


Table 1: Summary Statistics

	Mean	*Std. Dev*	*Min*	*Max*
Panel A: Marriage's characteristics				
Age at marriage	21.91	4.17	6.00	40.00
Marriage before 15	0.04	0.20	0.00	1.00
Marriage before 18	0.20	0.40	0.00	1.00
Brideprice	0.81	0.39	0.00	1.00
Brideprice amount (TZS)	98,862	127,900	0.00	997,842
Panel B: Demographic characteristics				
Female	0.59	0.49	0.00	1.00
Urban area	0.16	0.37	0.00	1.00
No education (mother)	0.09	0.19	0.00	1.00
Primary education (mother)	0.87	0.21	0.00	1.00
Secondary education (mother)	0.04	0.12	0.00	1.00
Tertiary education (mother)	0.01	0.03	0.00	1.00
No education (father)	0.10	0.22	0.00	1.00
Primary education (father)	0.72	0.31	0.00	1.00
Secondary education (father)	0.11	0.22	0.00	1.00
Tertiary education (father)	0.07	0.16	0.00	1.00
Bad House	0.20	0.40	0.00	1.00
Total consumption p/c (in TZS)	482,669	347,880	50,752	3,329,467
Food consumption p/c (in TZS)	302,000	196,611	25,197	1,600,864
Panel C: Rainfall measures				
Rainfall growing season	813.57	129.17	549.50	1188.99
Rainfall shock at age 15	93.38	88.81	0.63	365.73
Rainfall shock at age 16	97.87	89.00	0.63	359.96
Rainfall shock at age 17	102.76	89.80	0.63	359.96
Rainfall shock at age 18	105.51	95.96	0.63	413.01
Rainfall shock at age 19	105.83	93.42	0.63	351.06
Rainfall shock at age 20	114.36	97.49	0.63	413.01
Rainfall shock at age 21	105.13	84.78	0.63	359.96
Rainfall shock bw age 15-18	102.05	44.80	20.84	309.42
Rainfall shock bw age 16-18	110.10	61.13	14.52	314.97
Rainfall shock bw age 19-20	99.88	40.05	29.84	250.06
Rainfall shock bw age 19-21	108.44	45.51	20.84	309.42
Observations		1161		

Notes: Sample of respondents with non-missing value for the age of marriage. Rainfall shocks are computed as the absolute value of rainfall deviation (in millimetres) from the rainfall historical mean in each cluster from 1981 to 2010 in the six month of the growing seasons (March, April, May and October, November, December) at each age of the respondents. "Brideprice" is equal to 1 if there was a brideprice payment made for the marriage; The type of dwelling is described by the floor, the roof and the construction material of outside walls. Bad house 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. Source: Kagera Health Development Survey, 1991-2010 for demographic characteristics and NASA Langley Research Center for rainfall measures.

Table 2: Correlation between rainfall shocks and consumption

Dependent variable:	*Consumption p/c (log) (in TZS)*					*Food consumption p/c (log) (in TZS)*				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall deviation, t	0.028			0.031	0.031	0.031			0.036	0.036
	(0.025)			(0.025)	(0.024)	(0.028)			(0.027)	(0.026)
Rainfall deviation, t-1		-0.035***		-0.038***	-0.039***		-0.043***		-0.046***	-0.043***
		(0.011)		(0.011)	(0.012)		(0.012)		(0.013)	(0.013)
Rainfall deviation, t+1			-0.012		0.005			-0.025		-0.006
			(0.024)		(0.023)			(0.028)		(0.026)
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 Effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.370	0.370	0.369	0.370	0.370	0.332	0.333	0.332	0.333	0.333
Number of observations	8,075	8,075	8,075	8,075	8,075	8,079	8,079	8,079	8,079	8,079

Notes: OLS regression on a panel data of 8,084 households with cluster and wave fixed effects. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5% , * 10% significance. Constant not displayed. "Consumption p/c" include 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" is the household food consumption divided by the household size in the past 12 months. 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 month of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls include dummies for mother and father highest level of education, total value of durable assets held by the household, a dummy indicating urban areas and dummies for the head of household ethnic group. Source: Kagera Health Development Survey, 1991-2010.

Table 3: Probability of marriage by age 18, sample of females

Dependent variable: 1 if married before or at 18 years old	(1)	(2)	(3)	(4)	(5)
Rainfall shock at age 15			0.034		
			(0.049)		
Rainfall shock at age 16		0.005	0.001		
		(0.041)	(0.038)		
Rainfall shock at age 17	0.065	0.070*	0.080*		
	(0.042)	(0.040)	(0.042)		
Rainfall shock at age 18	0.102***	0.114***	0.110**		
	(0.039)	(0.043)	(0.043)		
Rainfall shock at age 19	0.003	-0.007	0.000		
	(0.031)	(0.036)	(0.037)		
Rainfall shock at age 20		-0.038	-0.034		
		(0.050)	(0.051)		
Rainfall shock at age 21			-0.033		
			(0.035)		
Rainfall shock at age 16-18				0.175***	
				(0.063)	
Rainfall shock at age 19-20				-0.040	
				(0.079)	
Rainfall shock at age 15-18					0.229***
					(0.087)
Rainfall shock at age 19-21					-0.045
					(0.080)
Urban district	-0.021	-0.023	-0.015	-0.026	-0.022
	(0.075)	(0.076)	(0.074)	(0.076)	(0.073)
Bad House	-0.014	-0.012	-0.014	-0.015	-0.020
	(0.047)	(0.047)	(0.046)	(0.046)	(0.046)
Mother Primary Education	-0.187	-0.183	-0.189	-0.179	-0.185
	(0.115)	(0.117)	(0.119)	(0.117)	(0.115)
Mother Secondary Education	-0.343**	-0.343**	-0.343**	-0.351**	-0.356**
	(0.166)	(0.164)	(0.167)	(0.169)	(0.170)
Mother Tertiary Education	-0.506***	-0.495***	-0.505***	-0.525***	-0.515***
	(0.140)	(0.143)	(0.146)	(0.141)	(0.136)
Father Primary Education	0.081	0.075	0.078	0.074	0.076
	(0.098)	(0.101)	(0.103)	(0.098)	(0.096)
Father Secondary Education	0.194	0.191	0.197	0.186	0.194
	(0.129)	(0.130)	(0.133)	(0.130)	(0.128)
Father Tertiary Education	0.007	0.003	0.004	0.006	0.009
	(0.133)	(0.135)	(0.137)	(0.136)	(0.136)
Village Fixed Effects	yes	yes	yes	yes	yes
Year of birth Fixed Effects	yes	yes	yes	yes	yes
R2	0.150	0.151	0.153	0.147	0.149
Observations	682	682	682	682	682

Notes: OLS regression on a cross sectional data. 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 month of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls also include dummies for the head of household ethnic group. Source: Kagera Health Development Survey, 1991-2010.

Table 4: Probability of marriage before 18, sample of males

Dependent variable: 1 if married before or at 18 years old					
	(1)	(2)	(3)	(4)	(5)
Rainfall shock, age 15			-0.003		
			(0.019)		
Rainfall shock, age 16		0.008	0.007		
		(0.013)	(0.015)		
Rainfall shock, age 17	-0.028*	-0.026	-0.025		
	(0.017)	(0.017)	(0.017)		
Rainfall shock, age 18	-0.015	-0.015	-0.014		
	(0.016)	(0.016)	(0.016)		
Rainfall shock, age 19	-0.018	-0.019	-0.018		
	(0.013)	(0.013)	(0.014)		
Rainfall shock, age 20		0.012	0.011		
		(0.017)	(0.019)		
Rainfall shock, age 21			-0.002		
			(0.019)		
Rainfall shock, age 16-18				-0.031	
				(0.030)	
Rainfall shock, age 19-20				0.003	
				(0.023)	
Rainfall shock, age 15-18					-0.037
					(0.045)
Rainfall shock, age 19-21					-0.008
					(0.041)
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	0.200	0.201	0.201	0.197	0.197
Observations	479	479	479	479	479

Notes: OLS regression on cross-sectional data. 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 month of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls include dummies for mother and father highest educational level,bad house (as descibed in table 1), a dummy indicating urban areas and dummies for the head of household ethnic group. Source: Kagera Health Development Survey, 1991-2010.

Table 5: Eldest girl in the household and the probability of child marriage

Dependent variable: 1 if married before or at 18 years old	(1)	(2)	(3)	(4)	(5)
Eldest, age 15*Rainfall shock, age 15			0.000		
			(0.001)		
Eldest, age 16*Rainfall shock, age 16		0.000	0.000		
		(0.001)	(0.001)		
Eldest, age 17*Rainfall shock, age 17	0.002***	0.002***	0.002***		
	(0.001)	(0.001)	(0.001)		
Eldest, age 18*Rainfall shock, age 18	0.000	0.000	0.000		
	(0.001)	(0.001)	(0.001)		
Eldest, age 19*Rainfall shock, age 19	0.001	0.001	0.001		
	(0.001)	(0.001)	(0.001)		
Eldest, age 20*Rainfall shock, age 20		-0.001	-0.000		
		(0.001)	(0.001)		
Eldest, age 21*Rainfall shock, age 21			0.001		
			(0.001)		
Eldest, age 16-18*Rainfall shock, age 16-18				0.001	
				(0.001)	
Eldest, age 19-20*Rainfall shock, age 19-20				-0.000	
				(0.001)	
Eldest, age 15-18*Rainfall shock, age 15-18					0.001
					(0.001)
Eldest, age 19-21*Rainfall shock, age 19-21					0.000
					(0.002)
Rainfall shock for all ages	yes	yes	yes	yes	yes
Eldest at all ages	yes	yes	yes	yes	yes
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	0.275	0.275	0.293	0.257	0.258
Observations	539	528	518	528	518

Notes: OLS regression on a cross sectional data. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5% , * 10% significance. Constant not displayed. Rainfall variables and controls as defined in table 3. Source: Kagera Health Development Survey, 1991-2010.

Table 6: Bride price and probability of marriage before 18, sample of females

Dependent variable: 1 if married before 18 years old										
	Brideprice					*No brideprice*				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall shock, age 15			-0.005					0.312		
			(0.056)					(0.250)		
Rainfall shock, age 16		-0.013	-0.026				0.142	0.156		
		(0.043)	(0.041)				(0.234)	(0.202)		
Rainfall shock, age 17	0.066	0.070	0.080			0.079	0.061	0.156		
	(0.051)	(0.051)	(0.051)			(0.126)	(0.136)	(0.160)		
Rainfall shock, age 18	0.150***	0.165***	0.170***			-0.051	-0.076	-0.251		
	(0.042)	(0.045)	(0.046)			(0.209)	(0.219)	(0.246)		
Rainfall shock, age 19	0.017	0.009	0.029			0.173	0.140	0.075		
	(0.036)	(0.040)	(0.044)			(0.111)	(0.148)	(0.130)		
Rainfall shock, age 20		-0.040	-0.048				0.006	0.230		
		(0.050)	(0.050)				(0.139)	(0.247)		
Rainfall shock, age 21			-0.055					0.075		
			(0.038)					(0.208)		
Rainfall shock, age 16-18				0.215**					0.124	
				(0.087)					(0.306)	
Rainfall shock, age 19-20				-0.023					0.077	
				(0.090)					(0.185)	
Rainfall shock, age 15-18					0.254**					0.318
					(0.109)					(0.328)
Rainfall shock, age 19-21					-0.046					0.211
					(0.089)					(0.360)
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 of birth Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.176	0.178	0.181	0.168	0.166	0.556	0.560	0.594	0.559	0.567
Observations	533	533	533	533	533	120	120	120	120	120

Notes: OLS regression on a cross sectional data. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5% , * 10% significance. Constant not displayed. Rainfall variables and controls as defined in table 3. Source: Kagera Health Development Survey, 1991-2010.

Table 7: Bride price and probability of marriage before 18, sample of males

Dependent variable: 1 if married before 18 years old										
			Brideprice					*No brideprice*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rainfall shock, age 15			0.022					0.107		
			(0.021)					(0.280)		
Rainfall shock, age 16		-0.025	-0.018				0.283	0.310		
		(0.017)	(0.021)				(0.348)	(0.380)		
Rainfall shock, age 17	-0.011	-0.011	-0.012			-0.002	-0.164	-0.226		
	(0.019)	(0.019)	(0.021)			(0.223)	(0.290)	(0.321)		
Rainfall shock, age 18	-0.007	-0.007	-0.004			-0.048	-0.080	-0.066		
	(0.018)	(0.019)	(0.020)			(0.158)	(0.222)	(0.189)		
Rainfall shock, age 19	0.003	0.007	0.007			0.041	-0.062	0.018		
	(0.019)	(0.018)	(0.019)			(0.189)	(0.213)	(0.257)		
Rainfall shock, age 20		0.022	0.029				-0.231	-0.316		
		(0.022)	(0.024)				(0.416)	(0.533)		
Rainfall shock, age 21			0.024					0.081		
			(0.025)					(0.279)		
Rainfall shock, age 16-18				-0.040					0.025	
				(0.031)					(0.239)	
Rainfall shock, age 19-20				0.028					0.040	
				(0.032)					(0.219)	
Rainfall shock, age 15-18					-0.008					0.014
					(0.049)					(0.198)
Rainfall shock, age 19-21					0.051					-0.020
					(0.050)					(0.413)
Controls	0.271	0.275	0.277	0.255	0.255	0.704	0.733	0.735	0.690	0.690
Village Fixed Effects	337	337	337	337	337	82	82	82	82	82
Year of birth Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
R2	0.176	0.178	0.181	0.168	0.166	0.556	0.560	0.594	0.559	0.567
Observations	533	533	533	533	533	120	120	120	120	120

Notes: OLS regression on a cross sectional data. Robust standard errors in parentheses, clustered at the village level. *** 1% , ** 5% , * 10% significance. Constant not displayed. Rainfall variables and controls as defined in table 3. Source: Kagera Health Development Survey, 1991-2010.

Appendix

Table A1: Probability of marriage before 18, sample of females

Dependent variable: age of marriage					
	(1)	(2)	(3)	(4)	(5)
Rainfall shock, age 15			-0.322		
			(0.356)		
Rainfall shock, age 16		0.367	0.249		
		(0.298)	(0.282)		
Rainfall shock, age 17	-0.167	-0.140	-0.146		
	(0.346)	(0.336)	(0.331)		
Rainfall shock, age 18	-0.502	-0.613*	-0.571*		
	(0.312)	(0.343)	(0.318)		
Rainfall shock, age 19	-0.034	-0.046	0.061		
	(0.250)	(0.301)	(0.279)		
Rainfall shock, age 20		0.090	-0.020		
		(0.400)	(0.434)		
Rainfall shock, age 21			-0.256		
			(0.252)		
Rainfall shock, age 16-18				-0.331	
				(0.514)	
Rainfall shock, age 19-20				0.018	
				(0.668)	
Rainfall shock, age 15-18					-0.752
					(0.638)
Rainfall shock, age 19-21					-0.333
					(0.675)
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	0.194	0.196	0.198	0.191	0.193
Observations	682	682	682	682	682

Notes: OLS regression on a cross sectional data. 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 month of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls as defined in table 3 Source: Kagera Health Development Survey, 1991-2010.

Table A2: Probability of marriage before 18, sample of males

Dependent variable: Age of Marriage					
	(1)	(2)	(3)	(4)	(5)
Rainfall shock, age 15			0.257		
			(0.266)		
Rainfall shock, age 16		-0.020	0.011		
		(0.470)	(0.464)		
Rainfall shock, age 17	0.053	0.071	0.105		
	(0.409)	(0.414)	(0.400)		
Rainfall shock, age 18	0.241	0.237	0.228		
	(0.433)	(0.427)	(0.434)		
Rainfall shock, age 19	0.337	0.344	0.337		
	(0.518)	(0.543)	(0.539)		
Rainfall shock, age 20		0.113	0.112		
		(0.366)	(0.389)		
Rainfall shock, age 21			-0.089		
			(0.294)		
Rainfall shock, age 16-18				0.300	
				(0.733)	
Rainfall shock, age 19-20				0.409	
				(0.664)	
Rainfall shock, age 15-18					0.641
					(0.760)
Rainfall shock, age 19-21					0.276
					(0.842)
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	0.315	0.315	0.316	0.315	0.315
Observations	479	479	479	479	479

Notes: OLS regression on cross-sectional data. 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 month of the growing seasons (March, April, May and October, November, December). All the coefficients (standard errors) are multiplied by 100. Controls as defined in table 3. Source: Kagera Health Development Survey, 1991-2010.