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On the Timing of Marriage, Cattle and Weather Shocks

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Abstract

In this paper we focus on the timing of marriages of women, whose marriages are associated with bride wealth payments, which are transfers from (the family of) the groom to the bride's family. Unmarried daughters could therefore be considered assets who, at times of need, can be cashed in. We investigate both theoretically and empirically to what extent the timing of a marriage of a daughter is affected by the economic conditions of the household from which she originates. We distinguish household specific wealth levels and two types of shocks: correlated (weather) shocks and idiosyncratic (wealth) shocks. We estimate a duration model using a unique panel survey of Zimbabwean smallholder farmers. The estimation results support the hypothesis that the timing of marriage is affected by household characteristics; girls from households that experienced a negative idiosyncratic (wealth) shock are more likely to marry.

1 Introduction

In developing countries economic markets are often absent or incomplete. The absence of economic markets is particularly severe in rural areas, where smallholder farmers lack access to formal financial and insurance institutions. This implies that these farmers often face liquidity constraints and that they cannot insure against a bad harvest or loss of livestock. Whereas a bad harvest has immediate but generally temporary consequences for farmers' welfare, the consequences for welfare of loss of livestock are long lasting. In rural Zimbabwe, for instance, income from agricultural production mainly depends on two factors, sufficient rainfall and the availability of cattle. Cattle are necessary as draft power for plowing. Without cattle households can only produce using the hoe, which yields little income. Loss of livestock might therefore lead to a household being stuck in poverty for a considerable period of time (see Carter and Zimmerman, 2000).

The lack of formal financial institutions does not allow farmers to borrow for investments in agricultural production or buying cattle. A large range of non-market solutions has become available to insure households against negative shocks and to allow them to smooth consumption over time. Examples of such non-market solutions are food sharing arrangements in which a household, who faced a negative idiosyncratic shock gets food from other households in the village, and labor sharing arrangements under which within a village farmers take care of the land of someone who is temporary unable to do so. Rosenzweig (2001) provides a review of the literature on informal insurance arrangements in low-income countries.

The focus of this paper is on the timing of marriage as an alternative institution for insurance against the loss of livestock. That marriage may act as a non-market insurance is due to the fact that marriages involve bride wealth payments. In the empirical analyses we consider rural Zimbabwe, where these payments are made by (the family of) the groom to the bride's family. Bride wealth comprises of a substantial number of cattle of which a considerable fraction is paid at the moment of the actual marriage. An unmarried daughter thus represents access to livestock and her marriage may be considered an asset that can be cashed in times of adversity. Because of bride wealth payments, marriages should be considered as a contract between two families rather than between two individuals. However, the choice of the spouse is generally not a household decision, but an individual decision. Therefore, we do not focus on the choice of spouses, but instead consider the timing of the marriage.

The bride's family can use the cattle obtained as bride wealth for increasing agricultural production and as buffer stock. The marriage decision of a daughter is therefore more likely to be a household decision in poor households than in wealthier households. In the empirical analyses, we investigate to what extent the timing of marriage of young women can be explained by the economic conditions of the households from which they originate.

There are many aspects to how shocks affect marriages. It is particularly important to distinguish between correlated shocks induced by a lack of sufficient rainfall and idiosyncratic shocks to households for example as a result of theft or death of cattle. Not surprisingly correlated and idiosyncratic shocks can have quite different effects on household behavior. Unlike idiosyncratic shocks, correlated shocks may have equilibrium effects on the marriage market. If after a year of low rainfall households press daughters to marry, households may prefer that sons do not marry. It may therefore be the case that after a year of low rainfall actually less marriages occur. This may have consequences for the amount of bride wealth. If after a year of low rainfall women are more eager to marry than men, then the amount of bride wealth is expected to be lower. We return to these issues in our theoretical model, where we will distinguish between correlated and idiosyncratic shocks. The theoretical model serves as a starting point for our empirical analyses where we consider the timing of a daughter's marriage and the amount of bride wealth. Also in the empirical model we distinguish between idiosyncratic and correlated shocks.

A strong impact of the household's economic situation on the timing of marriage suggests that formal risk sharing and credit markets work indeed unsatisfactorily. Such knowledge can be beneficial for policy, especially in the context of economic development. Furthermore, the presence of the use of bride wealth as an informal insurance device may cause women to marry younger. This may affect fertility, is likely to increase average household size, which has implications for population growth, poverty and - to the extend that poorer households are more likely to be larger - will increase inequality.

A dynamic model is required to empirically analyze the timing of a marriage. Such a model is required because the composition of the population of unmarried women in a particular year depends on marriages in previous years. If due to some shock, for example a drought, in a particular year many women in poor households marry, it follows that in the following year the population of unmarried women shifts towards women from richer households. To account for this we use hazard rates to model the age of marriage. We allow the transition rate from being unmarried to being married (the marriage rate) to depend on observed explanatory variables, both individual, household and environmental characteristics, on the elapsed duration of being unmarried (age), and on unobserved determinants. To model the relationship between the marriage rate and these variables, we use a Mixed Proportional Hazard specification (see e.g. Lancaster, 1990). To avoid initial conditions problems we use flow sampling to construct our data set. To separate idiosyncratic shocks from household specific wealth levels and correlated shocks, we use a dynamic model for household wealth accumulation. Finally, we also perform empirical analyses on the amount of bride wealth payments. However, due to the limited information on the amount of bride wealth involved with the observed marriages, the empirical results based on the size of bride wealth should be interpreted with care.

The data we use are from an annual panel survey held under a group of resettlement farmers in Zimbabwe which started in 1982. In the earlier surveys only household level variables were collected, but from 1994 onwards detailed information on all individual members of households is recorded. We use the subset of the data that starts in 1994, which includes approximately 400 households. The data on household members allows us to construct subsamples of unmarried daughters, which include information on the marriage decision, individual characteristics and some measures of household wealth. Since the data we use in the empirical analyses deal with farmers, in the remainder of the paper we restrict our discussions to farmers and rural areas.

The paper is organized as follows. In Section 2 the institution of marriage in rural Zimbabwe is considered in more detail. Section 3 presents both the theoretical and empirical model. Section 4 describes the data. The estimation results are presented in Section 5. Section 6 concludes.

2 Cattle and marriage in Zimbabwe

In the introduction the importance of cattle to Zimbabwean smallholder farmers as source of draft power for transportation and especially for plowing is already stressed. The heavy loam soils in rural Zimbabwe require at least two head of cattle, preferably trained oxes, to prepare land for sowing. Without two draft animals, a household has little choice but to rely on labor intensive land preparation using the hoe. The income obtained from farming manually is low, and insufficient to buy new cattle. Money can be obtained in off farm jobs, but these jobs are hard to find (during our observation period the urban unemployment rate was around 50%). Because of the absence of formal financial markets, borrowing money to buy cattle is impossible. A household without cattle can try to borrow cattle from neighbors after they are done with plowing. Typically, by the time the animals are available, the time for planting has passed while the beasts are tired from their earlier effort and of little use. Households without cattle can try to save (in the form of goats and chicken) from their meager crop incomes, and in this way accumulate the wealth to buy cattle. Yet it might take a long time before a sufficient amount is accumulated (Carter and Zimmerman, 2000). Households therefore have a strong incentive to avoid that the number of cattle becomes too small.

There are other reasons why cattle are of great significance to Zimbabwean farmers. Cattle provide milk, produce manure to fertilize the land and in times of need they can be eaten or sold in return for grain.[1] Selling cows to buy food is only relied upon as a measure of last resort. Fafchamps, Udry and Czukas (1998) show for Burkina Faso for instance that during long periods of drought, cattle sales only compensated 15% to 30% of income losses. Still, in Zimbabwe during the 1992 and 1995 droughts, the sale of cattle and other livestock was the single most important way to obtain cash to purchase food (see Kinsey, Burger and Gunning, 1998). The absence of formal financial institutions not only makes cattle an important buffer stock it is also an important means to keep savings (e.g. Fafchamps, Udry and Czukas, 1998; Rosenzweig and Wolpin, 1993). In this light, weight increase of a cow and the birth of a calf can be considered as interest on these savings, while the aging of the cattle represents inflation. Since the possession of cattle is vital for agricultural production, cattle ownership in Zimbabwe is highly correlated with other forms of asset ownership (Scoones, 1995). Furthermore, cattle can be used as legal tender. Not only to settle debt, but also in civil or criminal cases a traditional court may convict someone to pay a number of cattle. Finally, Tsodzo (1992) argues that also a great social value is attached to possessing many head of cattle (”he who dispenses with them, dispenses with good living”).

Next let us turn to the process of marriage in Zimbabwe. It is characterized by duality as the choice of one’s spouse is left to the individuals concerned, while the marriage itself is considered a contract between families. The latter is illustrated by the relationship terminology that is adopted. After marriage, the groom’s father-in-law becomes father-in-law to the whole of the groom’s family, while the father of the groom is regarded as the principle son-in-law rather than the groom himself. A brother of the groom is likely to speak in the first person saying “I have married such and such family”.

A marriage provides a bond between two families, and Zimbabwean families

[1] Fafchamps, Udry and Czukas (1998) note that African farmers rarely kill their cattle for eating the meat. Zimbabwean farmers may be even more reluctant to do so, since unlike in Burkina Faso, cattle are used for agricultural production.

related through marriage typically share resources in an effort to deal with risks. Families prefer to spread the net of affinal relations by marrying into different families. Marriages over a long distance or with someone with a job in town are considered with favor as these mitigate the impact of local weather shocks (see also Rosenzweig, 1988, and Rosenzweig and Stark, 1989).

Zimbabwean marriages include bride wealth payments, which are transfers from the family of the groom to the family of the bride. Bride wealth in Zimbabwe consists of two distinct payments, which are referred to as *rutsambo* and *danga*. *Rutsambo* is associated with sexual rights to the woman and after its payment the girl is allowed to move to her husband's household. *Danga* is associated with rights over children born to the woman. Cattle are the main body of the bride wealth. On average 9 head of cattle are demanded as bride wealth.

At the moment of marriage a substantial part of *danga* is paid, but the bulk of *danga* remains outstanding. Full payment of *danga* is extended over a long period of time. In Figure 1 we show how the fraction of marriages where all bride wealth payments are made evolves over the duration of the marriage. For less than 10% of the marriages all bride wealth payments are made in the first few years after the marriage. For over 80% of the marriages some part of the bride wealth payments is still outstanding after 25 years of marriage. The large drop occurs around 30 years of marriage, which implies that for most marriages the final bride wealth payments are made between 28 to 35 years of marriage. The bulk of the bride wealth thus remains outstanding after the marriage, which has advantages for both the family of the bride and the family of the groom. For the son-in-law, delayed payment implies that he can pay when he has the means to do so. Moreover, he can make sure that his wife is childbearing. Being barren is a valuable reason to undo a marriage. After a divorce or if the wife dies without giving birth to many children the husband can claim back (part of) the bride wealth. On the other hand, as long as the bride wealth is not completely paid, the family of the bride can ask the groom for favors in the form of services and gifts. This is illustrated by a Zimbabwean proverb saying: "A son-in-law is like a fruit tree: one never finishes eating from it". Furthermore, delayed payments secure that a household that loses its cattle still has access to some assets (see Dekker and Hoogeveen, 2002). Therefore, even if the son-in-law is in the position to pay all bride wealth upon marriage, it is considered a denial of the marriage bond between the families involved to actually do so.

The optimal timing of marriage is evident. Unless the household is very wealthy sons should marry late and daughters early. Late marriage of a son has several advantages. The son remains productive in the family's agricultural activities and the loss of draft power is postponed. If a household is poor, daughters should marry early. After the marriage of a daughter the previously poor family is able to experience a period of high productivity before the marriage of a son is supported. This period of high productivity can be used to accumulate more cattle and to grow out of the initial period of poverty. Another reason why daughters should marry young is that the amount of bride wealth decreases with age, which reflects that relative to older women, young women are likely to give birth to more children. National data confirm this pattern; the marriage age of men is much higher than of women (see Central Statistical Office, 1995). The median age at first marriage for men is 25 years, compared with 19 years for women. Only 11 percent of the men are married by the age of 20, compared to 62 percent of the women. In the next section we analyze the optimal timing of marriage in more detail by developing a theoretical model of household behavior.

3 Model

In this section we present our theoretical and empirical model. The theoretical model is a dynamic model of household behavior. The purpose of the model is to illustrate the effects of wealth, household size and shocks on the household's marriage decision. We do not estimate this model, but instead it serves as a starting point for the empirical analyses. The empirical model focuses on unmarried women and the transition rate to being married, i.e. the marriage rate. In the empirical model we explicitly take account of elements that are important in the theoretical model.

3.1 Theoretical model

In this subsection we provide a theoretical model of household behavior of Zimbabwean farmers. We explicitly model the household decision whether or not to marry off a daughter. In particular, we construct a discrete time dynamic programming model taking into account credit constraints, risk, and uncertainty (see for example Rosenzweig and Wolpin, 1993; and chapter 8 in Bardhan and Udry, 1999). It should be noted that in this model we ignore alternative consumption smoothing or risk-sharing mechanism mentioned in the introduction.

Upon resettlement each household was provided with 12 acres of land, which can be used for agricultural production. The land presented to the households is about 10% of the total area; the remaining 90% is common property land, which might be used for grazing. In our data 79% of the households uses less than the

12 acres of land for agricultural production, 9% uses exactly 12 acres and the remaining 12% uses more than 12 acres. For most households the availability of land is thus not the binding constraint in their agricultural production especially as households can use more than 12 acres of land if they (illegally) reclaim some common property land or rent land from other farmers.

Farmers in resettlement schemes differ from regular smallholder farmers in Zimbabwe. The resettlement farmers possess more land and until 1992 heads of households were not allowed to work off farm. This is reflected in the way income is generated. Unlike regular farmers who obtain approximately 30% of their income from non-farm sources, resettlement farmers earn only 5% to 10% of their income off farm. Farmers in the resettlement scheme are also somewhat wealthier than regular farmers and their per capita expenditures are about 10% higher than the per capita expenditures of ordinary smallholder farmers (Deininger and Hoogeveen, 2004).

The household's agricultural production depends mainly on three sources, the input of labor, the availability of cattle and the amount of rainfall. Let q_t denote the production of crop in year t, which follows the production function $f(B_t, M_t, R_t)$, where B_t is the head of cattle owned by the household, M_t is the number of (unmarried) daughters and R_t is (local) rainfall. The production function is increasing in its arguments. Because we are interested in the (marriage) behavior of daughters, we only include the number of daughters in the production function thereby assuming the number of sons fixed. As mentioned earlier at least two head of cattle are required for preparing the land for sowing, therefore we impose $q_t = 0$ if $B_t < 2$.

A household can use agricultural production to consume c_t or to save. Due to the lack of financial markets households save by extending their stock of cattle. The amount of consumption is decided after the household learns the production. Borrowing constraints cause that households can never consume more than the sum of their production and stock of cattle, i.e. $c_t \leq q_t + B_t$ (the price of cattle in crops is constant over time and normalized to 1). During a period of drought, farmers can sell some cattle to buy food necessary to survive (see Kinsey, Burger and Gunning, 1998). Yet because recovering from a period of drought is almost impossible without any cattle, they are very reluctant to sell cattle. Households can also accumulate cattle by marrying off a daughter. The marriage decision is made at the beginning of the period (before producing), but the marriage occurs at the end of the period (after consuming).[2] A household is allowed to marry off

[2]The rainy season is from the end of November until the beginning of April. This is immediately followed by the harvest period which takes until June/July. Marriages usually take place

at most 1 daughter each year. The variable m_t takes the value 1 if a daughter marries in period t and 0 otherwise. For obvious reasons a household can only marry off a daughter if there are unmarried daughters present, i.e. $m_t = 0$ if $M_t = 0$. The number of unmarried daughters in the household evolves according to $M_{t+1} = M_t - m_t$.

The household wealth is expressed by the stock of cattle B_t, which evolves over time according to the law of motion

$$B_{t+1} = \delta B_t + q_t - c_t + p_t m_t + \omega_t. \tag{1}$$

The parameter δ represents the growth rate of cattle, which is caused by strengthening of cattle, birth, death, aging, etc. One could argue that δ depends on the amount of rainfall, i.e. in dry years cows lose more weight or die sooner.[3] However, for sake of tractability and simplicity we assume δ to be a constant. The parameter p_t denotes the amount of bride wealth that is associated with marrying a daughter. For simplicity, we only take into account the initial payment and ignore subsequent payments in later periods (we return to this issue in Subsection 5.2). The amount of bride wealth is decided on the marriage market, so it can change over time due to covariate (rainfall) shocks. We return to this issue below. Cattle are subject to several (idiosyncratic) risks, denoted by ω_t, such as plagues like pests and theft. Pests have had devastating effects in the past, but are largely brought under control. Theft is a regular phenomenon, and can cause serious problems for the household. The lack of financial markets implies the restriction $B_t \geq 0$.

A household is assumed to exist for T periods and to maximize the expected present value of lifetime utility

$$U_t = E_t \sum_{\tau=t}^{T} (1+r)^{t-\tau} v(c_t),$$

Households derive utility from consumption c_t. The instantaneous utility of a household is given by $v(c_t)$, which is increasing in c_t.[4] Future utility is discounted at rate r.

in the fall.

[3] Scoones, Chibudu, Chikura, Jeranyama, Machaka, Machanja, Mavedzenge, Mombeshora, Mudhara, Mudziwo, Murimbarimba and Zirereza (1996) show that in the Chivi region (in Southern Zimbabwe) after the 1982-1984 droughts the number of households without cattle more than doubled from 23.3% to 50.7%.

[4] One may argue that the utility of a households does not only depend on the level of consumption, but also on the number of family members among which consumption is shared. Including this would make our model more complicated, but would not change the results.

The state variables of a household at the beginning of period t are B_t and M_t; cattle and unmarried daughters could be considered as the household's asset. The choice variables in this period are c_t and m_t. In the context of assets, marriages are used for portfolio diversification. There are two shocks, idiosyncratic (wealth) shocks ω_t and rainfall R_t. Both shocks are independent and identically distributed over time. For the moment, we assume that rainfall can also be interpreted as an idiosyncratic shock. In particular, the amount of bride wealth does not depend on rainfall, but we relax this later on. The model cannot be solved analytically, therefore we use simulation. We solve the model backwards and follow Keane and Wolpin (1994), by approximating the value function $U_t(B_t, M_t)$ for each value of $M_t = 0, 1, 2, \ldots$ as a higher order polynomial in B_t. As the marriage decision is made at the beginning of the period, at each period t, the optimal m_t only depends on the state variables B_t and M_t. The optimal decision of the household is illustrated in Figure 2. In this figure the optimal marriage strategy is depicted in the (M_t, B_t)-plane. The region denoted by $m_t = 0$ contains the combinations of cows and daughters for which it is optimal not to let her marry, while the opposite holds for the region with $m_t = 1$. In Appendix A we provide the specification and values of the parameters that gave this figure, but the general picture is not very sensitive to the choice of the functional forms and values of the parameters.

The figure shows that a household marries off a daughter if the number of daughters is high relative to the livestock wealth. In the current specification, both idiosyncratic (wealth) shocks and rainfall shocks affect the number of cattle owned by the household (one period later). Formal institutions that allow smallholder farmers to insure against negative shocks do not exist. Therefore, households have to use alternative ways to deal with negative shocks. Most households do not own a sufficient amount of cattle to deal with the consequences of negative shocks. When such a household is hit by a negative shock (in year $t-1$), the household might be pushed from the $m_t = 0$ area to the $m_t = 1$ area. In that case the household exercises the 'option value' of an unmarried daughter to raise the herd size.

So far, we considered both shocks as idiosyncratic shocks. However, the amount of rainfall does not vary much spatially, and therefore rainfall shocks are correlated and can have equilibrium effects. In particular, after a period of low rainfall, many households want to marry off a daughter, while not many households are willing to pay bride wealth for sons getting married. This reduces the amount of bride wealth paid by at marriage. We incorporate this in our model by allowing the amount of bride wealth p_t to depend on the rainfall on period earlier R_{t-1}. In Figure 3 we again show the optimal marriage decision in the (B_t, M_t)-plane for different levels of rainfall R_{t-1}. It is clear that for a given B_t households are more likely to marry off a daughter in periods of high rainfall, i.e. the $m_t = 1$ area is highest for $R_{t-1} = 0.9$. However, low rainfall R_{t-1} also reduces the amount of livestock one period later B_t. Therefore, the effect of low rainfall on marriage is ambiguous. Depending on the values of the parameters and in particular on how sensitive the amount of bride wealth is to rainfall, low rainfall can reduce the willingness of daughters to marry. In the next sections we empirically analyze the relation between shocks and the age of marriage. We distinguish between idiosyncratic shocks, such as theft and death of cattle, and correlated shocks, such as a period of drought. The testable implication is that idiosyncratic shocks affect the marriage behavior of women. After a negative shock households press their daughters to marry.

3.2 Specification of the statistical model

The theoretical model presented in the previous subsection provided some predictions. In this subsection we present our empirical model, which we use to test these predictions. We focus on unmarried women and the transition to being married. We allow this marriage rate to depend on age, some observed characteristics, such as household size, and covariate (rainfall) shocks and idiosyncratic wealth shocks. Idiosyncratic wealth shocks are unobserved. We cannot use wealth changes over years as idiosyncratic wealth shocks as these changes might for example also be affected by bride wealth payments or rainfall. To construct idiosyncratic wealth shocks, we use a dynamic model for wealth accumulation discussed in subsubsection 3.2.2. But first, we discuss the specification of the marriage rate.

3.2.1 The marriage rate

It is useful to start with a brief outline of our data and to provide some characteristics of the data that are relevant for the model. A more elaborate discussion of the data is given in the next section. The database includes unmarried women, who are interviewed yearly. At the moment of the interview the women are asked about their marital status and age. Additionally, a number of household characteristics are collected. This allows us to construct spells of being unmarried, although we do not observe the exact date of marriage and the date of birth, but only the years. Some women are still unmarried at the end of the observation period, and some other women left the database unmarried, for example because they temporarily moved to relatives. Such spells of being unmarried are right-censored, which we treat as exogenous.

We want to avoid initial conditions problems. Therefore, we construct a flow sample that only contains women who are observed from the moment they reach the age at which they start getting married. It is clear that it is not necessary to observe women from the moment of birth: it is sufficient to follow them from the age they start marrying. We set the minimum age of marrying at 15, which is denoted by t_0. This minimum age is not due to legal restrictions, but reflects the age the statistical bureau of Zimbabwe uses as lower bound for the age at marriage. Of the women born between 1975 and 1980 less than 3 percent was reported to be married by the age of 15 (Central Statistical Office, 1995). This is also confirmed by our data, which does not show any marriages of women under age 15. Since the flow sample only includes women reaching age 15 during the observation period, the cost of avoiding initial condition problems is ignoring a large share of the available data. However, the great benefit is that we do not have to make stationarity assumptions (see Ridder, 1984).

Age and calendar time are genuinely continuous, but we only observe in which year a woman got married. To deal with this discrepancy, we use an underlying continuous-time marriage rate to model the probability that an unmarried woman of age $t \geq t_0$ at calendar time τ marries before calendar time $\tau + 1$. Since we do not observe the exact date of birth, but only the age at the moment of the interview, we integrate over the possible dates of birth. We assume that the differences in transition rate from unmarried to married can be characterized a vector of observed characteristics x_τ (for example household size and rainfall in year τ), unobserved individual characteristics v and the elapsed duration of being unmarried t (age of the unmarried woman). We assume v to be independent of x_τ and τ. The unobserved characteristics are individual specific and not household specific. Changes over time in x_τ are assumed to be exogenous and unpredictable.

The marriage rate at age t conditional on x_τ and v is denoted by $\lambda(t|x_\tau, v)$ and is assumed to have the familiar Mixed Proportional Hazard (MPH) specification

$$\lambda(t|x_\tau, v) = \psi(t) \exp(x_\tau \beta + v),$$

in which $\psi(t)$ is a positive function representing the baseline hazard or age dependence. Let t be the actual age when getting married and τ_0 the calendar time at birth. The conditional density function of $t|x_{\tau_0+t_0}, \ldots, x_{\tau_0+t}, v$ can be written as

$$f(t|x_{\tau_0+t_0}, \ldots, x_{\tau_0+t}, v) = \lambda(t|x_{\tau_0+t}, v) \exp\left(-\int_{t_0}^{t} \lambda(s|x_{\tau_0+s}, v)\mathrm{d}s\right), \qquad t \geq t_0.$$

The conditional survivor function of $t|\tau_0, x, v$, i.e. the conditional probability that the duration of being unmarried exceeds t, equals

$$S(t|x_{\tau_0+t_0},\ldots,x_{\tau_0+t},v)=\exp\left(-\int_{t_0}^{t}\lambda(s|x_{\tau_0+s},v)\mathrm{d}s\right),\qquad t\geq t_0.$$

Obviously, $S(t|x_{\tau_0+t_0},\ldots,x_{\tau_0+t},v)=1$ if $t<t_0$.

Note that in the model we treat each woman as an independent observation. This is not completely correct as some women live as sisters in the same household. For a household with only few head of cattle, one of the daughters getting married can be sufficient to avoid future poverty, implying dependency between the marriage rates of sisters. In particular the marriage rates between sisters are likely to be negatively correlated. It also implies that by treating sisters as independent, we underestimate the effect of household's economic conditions on the marriage rate. We do not correct for this. The parameters we estimate are no policy parameters and therefore we are more interested in their signs rather than their exact values.

We have to integrate over yearly intervals in which women reached age 15 and got married. Let T be the stochastic variable denoting the date at which a woman gets married. Conditional on the year of inflow in the sample τ_0+t_0, i.e. the year in which the women became 15 and the vectors of explanatory variables x_τ, $\tau=\tau_0+t_0,\tau_0+t_0+1,\ldots$, the probability of getting married between year τ^* and τ^*+1 equals

$$\begin{aligned}&\Pr(T\in[\tau^*,\tau^*+1)|x_{\tau_0+t_0},\ldots,x_{\tau^*})\\&\quad=\int_{\tau^*-\tau_0+t_0}^{\tau^*-\tau_0+t_0+1}\int_{t_0}^{t_0+1}\int_{v}f(r+p|\tau_0+t_0-p,x_{\tau_0+t_0},\ldots,x_{\tau^*},v)\mathrm{d}G(v)\mathrm{d}p\mathrm{d}r\end{aligned}$$

where $G(v)$ is the distribution function of the unobserved characteristic v. The individual contributions to the loglikelihood function are based on this distribution function. Within this hazard rate framework right-censoring, i.e. a woman is still unmarried at the end of the observation period, is solved in a straightforward manner.

For the baseline hazard function, $\psi(t)$, and the unobserved heterogeneity distribution, $G(v)$, we take the most flexible specifications used to date. We take $\psi(t)$ to have a piecewise constant specification,

$$\psi(t)=\exp\left(\sum_{j=1,2,\ldots}\lambda_j I_j\left(t\right)\right),$$

where j is a subscript denoting time intervals and $I_j(t)$ are time-varying dummy variables that are equal to one in consecutive time intervals. Note that with an increasing number of time intervals any pattern can be approximated arbitrarily closely. We take these time intervals equal to two years.

We take the distribution of the unobserved heterogeneity $G(v)$ to be a discrete distribution with a fixed number of unrestricted mass point locations. Let v_i, $i = 1, \ldots, m$ be the points of support and let p_i, $i = 1, \ldots, m$ be the associated probabilities, i.e. $p_i = \Pr(v = v_i)$, where $0 \leq p_i \leq 1$, $i, = 1, \ldots, m$ and $p_m = 1 - p_1 - \ldots - p_{m-1}$. Note that discrete distributions are advantageous not only from the point of flexibility but also from a computational point of view.

3.2.2 Idiosyncratic wealth shocks

The theoretical model stressed the relation between the household's livestock wealth and marriage decisions. There are some disadvantages to taking household's livestock wealth as regressor in the model. Households may differ in their preferences (instantaneous utility function or discount rate) or production function (land quality or available equipment), and therefore there can be households that are always poor or households that are always rich. Girls from poorer households may prefer to marry younger for instance because living in a poor household is not very pleasant. Therefore, we want to distinguish between a household's livestock wealth level and idiosyncratic shocks in the household's livestock wealth level. To get an indication on how big shocks in household wealth are compared to the distribution of wealth between the households, we compare the average standard deviation of livestock wealth of households (over the years) with the standard deviation of average wealth of households (over the years). The average value of livestock is around 11.7 cows, the average standard deviation of household livestock wealth 3.3 cows and the standard deviation of average wealth of households 8.9 cows. This implies that there are indeed generally richer and poorer households, but being rich in one particular year does not guarantee being rich in the next year. In general, we see that the average livestock wealth of households is increasing during the observation period as households are recovering from the drought in 1991/1992.

For obvious reasons idiosyncratic shocks in the households livestock wealth are nor directly observed in the data. We cannot simply take the idiosyncratic shocks equal to difference in livestock wealth in a particular year compared to the average during the observation period. If a marriage occurs the bride wealth payments increase the mean household's livestock wealth, which implies that before the moment of the marriage the shock would be too low and after the moment of marriage too high. This might cause spurious relations between shocks and the marriage rate. Similar problems arise if we would define the shock as the difference in livestock wealth in subsequent years. Therefore, to construct shocks in household's livestock wealth (and the household's livestock wealth level), we estimate a dynamic panel data model for livestock wealth accumulation (that also takes marriages and rainfall shocks into account). First, we provide and estimate the model for livestock wealth accumulation and next we discuss how these estimation results are used in estimating the marriage rate (details are provided in Appendix B).

Our data set contains information on H households that are denoted by $h = 1, \dots, H$. The panel is unbalanced, however, the number of years T_h for which we observe household h is exogenous. The theoretical model predicts that the household's livestock wealth $B_{h,t}$ (measured in cows) depends on (i) the household's livestock wealth one year earlier $B_{h,t-1}$, (ii) a dummy variable $m_{h,t}$ that indicates if a daughter in the household married between the survey in year $t-1$ and year t,[5] (iii) the size of the household $S_{h,t-1}$ during the survey in year $t-1$, (iv) the amount of rainfall R_{t-1} in year $t-1$, and (v) some household characteristics z_h that are constant over time. These latter household characteristics include region, faith and living in a single-headed household.

The household's livestock wealth accumulates according to the model

$$B_{h,t} = \beta_0 + \beta_1 B_{h,t-1} + \beta_2 m_{h,t} + \beta_3 S_{h,t-1} + \beta_4 R_{t-1} + z_h \beta_5 + \eta_h + \varepsilon_{h,t},$$

where η_h is an unobserved household specific wealth component and $\varepsilon_{h,t}$ are idiosyncratic wealth shocks. These are the two components that we want to include as regressors in the marriage rate. This model for livestock wealth accumulation can be interpreted as the reduced-form of equation (1) in the theoretical model.

The marriage rate is specified at the level of daughters instead of households. Woman $i = 1, \dots, N$ lives in a household with household specific effect η_i and yearly shocks are $\varepsilon_{i,1}, \dots, \varepsilon_{i,T}$. The characteristics of the women are given by $x_{i,\tau}$, where τ denotes the year in which these are observed. As shown above the likelihood function equals

$$\prod_{i=1}^{N} \Pr(T \in [\tau_i^*, \tau_i^* + 1) | x_{\tau_{0,i}+t_0}, \dots, x_{\tau_i^*}, \eta_i, \varepsilon_{i,\tau_{0,i}+t_o}, \dots, \varepsilon_{i,\tau_i^*})$$

If we would know the values of η_i and $\varepsilon_{i,\tau}$, we could just optimize the logarithm of this likelihood function to obtain the parameter estimates. However, instead

[5] As mentioned earlier not all bride wealth is paid in the year of marriage, which might suggest that we should also include the dummy variables for marriages lagged. However, bride wealth payments are most substantial in the year of marriage and bride wealth payment schemes are not similar. Furthermore, we do not observe marriages occurring before 1994, so including these lagged variable would reduce the length of our panel considerably.

of η_i and $\varepsilon_{i,\tau}$ we observe the estimated residuals $\hat{v}_{i,\tau}$ (see for details Appendix B). Therefore we optimize the loglikelihood function

$$\log\left(\int \prod_{i=1}^{N} \Pr(T \in [\tau_i^*, \tau_i^* + 1) | x_{\tau_{0,i}+t_0}, \ldots, x_{\tau_i^*}, \eta_i, \varepsilon_{i,\tau_{0,i}+t_0}, \ldots, \varepsilon_{i,\tau_i^*}) f(\eta, \varepsilon|\hat{v}) \, \mathrm{d}(\eta, \varepsilon)\right)$$

where η is a vector containing all household specific effects, ε is a matrix containing for all households all yearly shocks and $\hat{v}$ is a matrix containing the estimated residuals $\hat{v}_{h,t}$. In Appendix B we provide in detail the derivation of the density function $f(\eta, \varepsilon|\hat{v})$.

To optimize the loglikelihood function given above we use simulated maximum likelihood estimation (e.g. Stern, 1997). We draw 1000 times from the distribution $f(\eta, \varepsilon|\hat{v})$. For each draw $j = 1, \ldots, 1000$ we follow procedure: (i) given the values $\hat{v}$ we generate a matrix v_j, (ii) we generate a vector η_j with household specific effects from a normal distribution with mean 0 and variance $\hat{\sigma}_\eta^2$, (iii) we compute the matrix of shocks $\varepsilon_j = v_j - \eta_j$, (iv) we compute the individual likelihood contribution, (v) we sum the logarithm of the individual likelihood contributions and maximize this sum.

4 Data

The data set we use is a yearly panel of Zimbabwean smallholder farmers covering the period 1994 until 2000.[6] These households belong to the group of about 25,000 families that have been resettled in the early 1980s on land acquired from large-scale farmers after the independence. Approximately 400 households are interviewed, living in three different regions (Mpfurudzi, Sengezi and Mutanda). These schemes were chosen to ensure representation of each of the three major agro-ecological zones in the country which are suited for cropping. Farmers located in Mpfurudzi live in the area most favorable to farming, those in Mutanda have to deal with the worst conditions. Those resettled in Sengezi live in an intermediate area.

The data are collected by Bill Kinsey and are described in more detail in Kinsey, Burger and Gunning (1998). The interviews take place in the beginning of the year, and thus describe the previous year. Starting in 1994 information on all household members is collected along with household level variables (whereas

[6]The data also includes the survey for 2001. However, we decided not to use this information because starting in 2000 large changes took place in Zimbabwe, especially in the political situation regarding land reform.

the 1993 interview only collected household level information). At the household level variables such as crop income and livestock possession are administered. The questions to the individuals are about age, level of education, gender, marital status, etc. If an individual is not present at the time of the survey, but was recorded as a household member in a previous survey, the reason is asked why the individual left the household. Women generally leave the household upon marriage. So by comparing presence in the household and marital status in consecutive years, it is possible to construct spells of being unmarried.[7]

Since we are interested in the marriage behavior of young women, we only use the subset of the data consisting of all unmarried women whose age exceeds 15 years at some interview. Furthermore, we restrict the subsample to women under the age 30, as older unmarried women are often divorced or widowed. In total we observe 691 unmarried women over the age 15, of which in total 233 got married during the observation period. We refer to this sample as the stock sample. The empirical marriage rate is shown in Figure 4. It reflects an increasing pattern until age 21. After that the empirical marriage rate fluctuates, but there is no clear trend. Figure 5 shows the corresponding Kaplan-Meier estimates of the survival probabilities, i.e. the probability that a woman is still unmarried at a particular age. Most women marry before age 30, only 4% is still unmarried at this age. At age 22 over 60% of the women has got married. The median age of marrying in our data is around 21 years and thus higher than the median marriage age in Zimbabwe, which is 19 years (see Section 2). Remember that our data describe a very specific rural area, where the (resettlement) farmers are on average somewhat richer than other farmers.

In Table 1 we present some annual statistics of the data, such as the number of marriages, the average marital age and both local and average rainfall in Zimbabwe.[8] We have stratified the sample by the region in which the women live. For each of the three regions both the number of marriages and the average age of marriage decrease over the years. Also the sample size decreases over the years. This is caused by the original sampling of the data, which includes households of which the man was between 35 and 50 years old in 1982.[9] This implies that more women leave the sample (for reason of marriage), than young (unmarried)

[7]Generally daughters do not leave the household for reasons other than marriage. Sons are much more likely to leave the household unmarried to seek employment in town and get married while they are in town. This makes it more difficult to focus on the marriage behavior of sons.

[8]The local rainfall data and the Zimbabwean rainfall data are collected by the Department of Meteorological Services in Zimbabwe.

[9]A family remains in the data until both the man and woman die. After that this household is replaced by the people who move into their house (most likely sons or daughters).

women enter the sample (because they reach age 15). Local rainfall is correlated with average rainfall in Zimbabwe, but there is variation between the regions. In each of the regions rainfall was lowest in 1994/1995, which affects the marriage in the Fall of 1995. The data do not show strong differences in the number of marriages and the average age of marriage between the years with a large and low amount of rainfall.

Table 2 provides the average marriage age stratified by the year of marriage and the herd size of the household. In most years, daughters in the less wealthy families marry younger than in the wealthier families. However, the differences are not very pronounced.

By constructing a flow sample (ref. Section 3.2.1 we restrict the data further to all women who reached age 15 during the observation period. This gives a sample of 333 women (originating from 302 different households), of which 57 got married during the observation period. Table 4 shows the number of women in the flow sample at the beginning of a year and the number of marriages in that year. Because the sample size is relatively small we do not stratify by region. It is clear from the table that most marriages occur in the last three years of the observation period. During the first three years, the women in the flow sample are all younger than 18 years. The marriage rate for this age group is low (as can be seen from the empirical marriage rate in Figure 4).

In Table 5 we show the average livestock wealth in each year for the subsample of women who got married in that year and those who remained unmarried. We see that in each year except for 1999, the women who got married came from poorer households. Recall that in the first three years the number of marriages was very low. The difference in wealth between the subsamples is particularly large in 1998, which was a year following the relative dry year 1997. This seems to confirm that after a negative shock women in poor households are more likely to get married. But we cannot rule out that that there are households that are always poor and households that are always rich and that girls from poorer households prefer to marry younger. On average the women in our sample live in a household containing around 12 persons (including the parents). Another variable we include is an indicator for being the oldest unmarried daughter in the household. If the timing of a marriage is indeed a household decision, a (temporarily) poor household will most likely put pressure on the oldest unmarried daughter to get married. Furthermore, we use region and faith as explanatory variables. Most women in the sample live in villages in Mpfurudzi. In terms of religious denomination around 17% of the women reports to have African faith and 7% Masowe faith. The remaining women mostly have Christian faith, which is generally less strict than the African and Masowe faith. For around 11% of the women household characteristics are missing, we include a dummy variable for these women. In 17% of the cases the father is missing in the household and in 2% the mother.

The data contain some information on the amount of bride wealth paid (and especially on the amount of *danga*, i.e. the most substation payment related to the rights over children, see Section 2). This variable needs to be interpreted with care. The information on bride wealth paid is affected by item non-response, and bride wealth paid is only observed at the household level, as the total amount of bride wealth obtained in the previous year. It is thus not related to a particular marriage. By combining the individual data on marriages with the household data on bride wealth, we relate bride wealth to marriages. In particular, if we observe the household receiving bride wealth we link this to the most recent marriage that occurred in this household. For the year 2000 we did not obtain any information on bride wealth.

On the basis of the bride wealth data, we create two variables. The first variable contains the amount of bride wealth received by the household in the year of marriage, which we refer to as short-term bride wealth. The second variable, which is called long-term bride wealth is the accumulated amount of bride wealth received by the household in the year of marriage and the following years in the observation period. However, recall that it usually takes around 30 years until the total amount of bride wealth has been paid, while we only observe yearly payments over a maximum of 5 years. The total amount of bride wealth we observe is therefore an underestimate of the actual total amount. We restrict our attention to households for which we observe household characteristics. For these households we observe 424 marriages in the data. However, we only find bride wealth information for 128 of them. In the sample the average bride wealth consisted of around 1300 Zimbabwean dollars (either in cash or in cattle).

With respect to long-term bride wealth we only include marriages until 1997, otherwise the total observed bride wealth would be too much affected by the remaining length of the observation period after the year of marriage. This subsample includes 174 marriages. For 156 of these 174 we observe bride wealth. The average bride wealth was approximately 2200 Zimbabwean dollar.

5 Estimation results

In this section we present the estimation results of the empirical analyses. We first discuss the estimation results for the marriage rate. After that we consider estimation results concerning the amount of bride wealth.

5.1 Estimation results for the marriage rate

The parameter estimates of the flow sample procedure are presented in Table 6. We do not find any significant unobserved heterogeneity. During the optimization of the loglikelihood function both mass points converge to a single mass point. The baseline hazard shows how the marriage rate is affected by the age of an unmarried woman. It shows that the marriage rate increases with age. The marriage rate is highest for women living in Mpfurundi. The women in the other regions on average marry later. Women with African faith marry later than women with Masowe faith or Christian faith.

One of the parameters of interest is the effect of the amount of rainfall on the marriage rate. Our theoretical model showed that the effect of rainfall on marriages could either be positive or negative, depending on the sensitivity of the amount of bride wealth on rainfall. The estimates show that the effect of rainfall on the marriage rate is positive (but not significantly different from 0), implying that more marriages occur after a season with more rainfall. During the observation period the quantity of rainfall varied from around 0.5 meter in 1994 to around 1 meter in 1996 and 1998, which implies that in 1999 the marriage rate was on average only around 38% higher than in 1995, i.e. $\exp(0.64 \cdot 0.5) - 1 \approx 0.38$. As mentioned before local rainfall is correlated with the average rainfall in Zimbabwe (e.g. Table 1). The effect of the amount of rainfall in this case is thus merely a marriage market effect. Like brides (and their families) grooms suffer from the negative weather shocks as well. After a drought they are likely to be reluctant to get married and to pay bride wealth. So even if households put pressure on their daughters to get married after a dry season, the number of marriages might increase little because of the unavailability of grooms. The reduction in the number of marriages after a period of low rainfall, implies that rainfall must have a negative effect on the amount of bride wealth. We return to this issue in the next subsection.

The effect of being the oldest unmarried daughter in the household is positive. The marriage rate of the oldest daughter is 67% ($= \exp(0.51) - 1$) higher than the marriage of a girl of the same age, who has an older unmarried sister. This is in agreement with the hypothesis that the timing of marriage is a household decision rather than an individual decision. In case a household would like one of their daughters to get married, the oldest daughter is most likely to be pressed to do so. There are two main reasons for this. First, the amount of bride wealth is decreasing faster in age for older girls (if a women marries at young age, she will most likely have more children). So, the opportunity costs of staying unmarried for some period are highest for the oldest daughter in the household. Second, other daughters could easily argue against the parents' pressure to marry on the ground that they have an older unmarried sister. Since the model takes account of the age of women, this is not a spurious effect due to the fact that the average age of oldest daughters is most likely to be higher than of the other unmarried women.

As predicted by our theoretical model, the size of the household has a significant positive effect on the marriage rate, implying that daughters living in larger households marry on average younger. In larger households the loss of labor due to a marriage is less severe, the marginal productivity of a daughter in larger households is smaller than in smaller households. Alternatively, large households are likely to have many sons, which are (due to bride wealth) claims on household wealth. Ideally, the marriage of a daughter precedes the marriage of a son, and thus women living in households with many brothers have more pressure to marry. Therefore, we have tried to replace household size with the number of sons in the household. This did not affect the parameter estimate. Both variables are too correlated to include them jointly.

The effect of living in a single-headed household is positive which suggests that women in single-headed households marry earlier. We do not know the reason why a parent is absent, but recall that the father is much more often absent than the mother, in 17% and 2% of the households respectively. A father who is absent may work in the city, although as noted earlier finding work in the city is difficult. If the father is absent because of work in the city, the yearly income of the household is likely to be more stable. Therefore, household behavior is less sensitive to shocks and their need for cattle (as buffer stock) is reduced. The latter corresponds to the empirical fact that single-headed households are less well endowed with livestock than two-parent households, their livestock wealth is about 20% lower. If the father works in the city, the household is less dependent on the income from agriculture, which means that the household does not need the labor of the children (although it might be that in single-headed households children have to perform (part of) the tasks of the missing parent). This lowers the marginal productivity of a child in a single-headed family, and therefore the girls marry at a younger age.

The last regressors in the model describe livestock wealth in the household. The effect of a idiosyncratic shocks on livestock wealth $\varepsilon_{i,t}$ is more important than differences between household specific components η_i. After a negative shock in the household's livestock wealth, the marriage rate increases significantly. If a household loses 2 head of cattle, due to an unanticipated event such as theft, the marriage rate of daughters in this household increases with around 22%. This is in agreement with the theoretical model. The covariate effect of the household specific wealth component η_i is also negative, but not significant. Women from less wealthy households marry at a younger age than women from richer households. Daughters living in poor household have a strong incentive to leave the household, just to escape bad living conditions.

We have tried adding other explanatory variables to the model. However, this did not improve the fit, i.e. the parameter estimates were very close to 0 with relatively large standard errors and no improvement in the loglikelihood function. In particular, we added equipment owned by the household and total acres of land used in agricultural production. It should be stressed that these variables are highly correlated with livestock wealth, which implies that potential covariate effects of such regressors are already covered by livestock wealth.

5.2 Analyzing the amount of bride wealth payments

Finally, we performed some empirical analyses on the amount of the bride wealth. As mentioned in Section 4 the data on the amount of the bride wealth are not very precise and do not cover a sufficiently long period to observe the payment of total bride wealth as payments most often take as much as 30 years. We only observe the total amount of bride wealth received in a particular year, which we link to the most recent marriage in the household. This is a strong assumption and therefore the estimation results should be interpreted with care. For the empirical analyses we use tobit models.[10] We perform two analyses, the first based on the amount of bride wealth received during the year of marriage and the second based on the accumulated amount of bride wealth received during the observation period after the marriage. The latter also includes the bride wealth

[10]Since we only observe the amount of bride wealth for a subsample of the data, the ideal model would be a sample selection model. However, identification of sample selection models hinges on exclusion restrictions. In our data there is no variable that would qualify for being excluded from the equation denoting the amount of bride wealth, but included in the equation describing if the household reports having received bride wealth. Therefore, we use a simpler censored regression or tobit model,

$$y^* = x\beta + \varepsilon$$

and

$$y = \begin{cases} y^* & \text{if} \quad y^* > 0 \\ 0 & \text{if} \quad y^* \leq 0 \end{cases}$$

The interpretation of this model is that bride wealth is observed with a large measurement error ε, and that households only report having received bride wealth if the bride wealth including the measurement error exceeds 0.

received in the year of marriage. As explanatory variables we include age of the daughter at the moment of marriage, amount of rainfall, an indicator for being the oldest daughter and livestock wealth in the year before marriage.

The estimation results are given in Table 7. Except for rainfall all covariate effects on the amount of bride wealth received in the year of marriage, are opposite to the effect on the total amount of the bride wealth. Obviously, some households prefer a relatively large amount of bride wealth at the moment of marriage over a larger over-all amount of bride wealth. The amount of bride wealth received at the first year is higher in relatively dry years, for poorer households and if it is the oldest daughter who marries. Above we already explained that since we also correct for age, the dummy variable for oldest daughter can be interpreted as an indicator for household pressure. It is clear that households who bargain for a relatively large initial payment of bride wealth, have to accept low payments in the following years. This observation is in accordance with our theoretical model, poor households need sufficient cattle for agricultural production. Therefore, they need a substantial initial transfer, which is obviously followed by a period with low transfers follows.

Even though very insignificant, the effect of rainfall on the amount of bride wealth seems to contradict our theoretical model. We would expect that after periods of low rainfall, bride wealth payment would be lower, the estimation results show the opposite. Recall that we found that the marriage rate decreased in periods of low rainfall. Those marriages that actually take place after a period of low rainfall might therefore be selective, the groom should come from a wealthy family as this family is capable of paying bride wealth after a period of low rainfall. The empirical result can be explained if people from relatively wealthy families mostly marry people from wealthy families and these marriages involve larger amounts of bride wealth.

6 Conclusions

This paper focuses on the timing of marriage in rural areas in Zimbabwe. In these rural areas farmers live who obtained 12 acres of land from a resettlement program in the early 1980s. To work the land cattle is required; without cattle agricultural production is minimal. The absence of access to formal financial institutions to smallholder farmers causes that households cannot borrow to buy cattle if they do not possess sufficient cattle for plowing. Since finding off-farm jobs is extremely difficult and the return to manually working the fields is low, households without cattle may get stuck in poverty for a long period. Due to the existence of bride wealth, which is a transfer from (the family of) the groom to the family of the bride, a daughter's marriage is a possibility to acquire cattle. An unmarried daughter could therefore be considered as an asset that can be cashed in bad times.

To guide interpretation for the empirical analyses, we have developed a dynamic model for the household behavior of Zimbabwean smallholder farmers. In particular, we have considered the effects of household size, livestock wealth and covariate and idiosyncratic shocks on marriage behavior. In the empirical analysis we focus on the influence of weather shocks and (shocks to) household cattle wealth on the timing of a daughter's marriage. For the empirical analyses we rely on a unique panel data set on Zimbabwean smallholder farmers. In the data we find that the wealth of these smallholder farmers fluctuates enormously over the years, i.e. being wealthy in a particular does not guarantee being wealthy in next years. If indeed the marriage behavior depends on shocks, the composition of the population of unmarried women in a year depends on shocks in the previous years. To take account of these dynamics, we use a mixed proportional hazard rate framework to model the age of marriage.

By focusing on the timing of a marriage of a daughter, we only provide a partial picture on the marriage market. However, the lack of information on the choice of spouses makes it impossible to extend this picture.

The estimation results show that the amount of rainfall has a positive effect on the marriage rate, which is most likely a marriage market effect, i.e. after a period of low rainfall the supply of men is lower as not that many households are capable of paying bride wealth. The marriage rate of daughters is higher for poorer households. In particular, after a negative shock in livestock wealth the marriage rate of daughters increases. Furthermore, the marriage rate for the oldest daughter in the household is higher. Both these effects confirm the hypothesis that households use an unmarried daughter as an asset that can be cashed in bad times. The marriage decision should therefore not only be considered as a decision of the individuals involved, but also as a household decision.

We also considered the amount of bride wealth. These estimation results provide additional evidence that the timing of marriage is used as means to avoid getting stuck in poverty. In particular, less wealthy households receive a larger initial payment at the moment a daughter gets married. The accumulated amount of bride wealth they receive in the first years of marriage is relatively low, so that the relatively high initial payment goes at the expense of subsequent payments. In other words, a period of poverty is only avoided at the expense of receiving lower payments in the subsequent years.

Our results have policy relevance. In particular, the use of marriage as an alternative financial institution affects the age at which daughters marry. This might have negative external effects. If women marry young, they are more likely to have more children. Furthermore, households might want to have at least a particular number of daughters to act as insurance against negative shocks. Relatively large household have less resources per child to invest in health and schooling of children. Especially, girls will suffer as they are pressed to marry young. This may cause poverty to be transmitted across generations.

References

Bardhan, P. and C. Udry (1999), *Development Microeconomics*, Oxford University Press, Oxford.

Carter, M.R. and F.J. Zimmerman (2000), The dynamic cost and persistence of asset inequality in an agrarian economy, *Journal of Development Economics* 63, 265–302.

Central Statistical Office (1995), *Demographic and Health Survey 1994*, Harare, Zimbabwe.

Deininger, K. and J.G.M Hoogeveen (2004) Economic Costs and Benefits of Land Redistribution in Zimbabwe *World Development*, forthcoming.

Dekker, M. and J.G.M. Hoogeveen (2002), Bride wealth and household security in rural zimbabwe, *Journal of African Economies* 11, 114–145.

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

Keane, M.P. and K.I. Wolpin, 1994, The Solution and Estimation of Discrete Dynamic Choice Programming Models by Simulation and Interpolation: Monte Carlo Evidence, *Review of Economics and Statistics* 76, 648–672.

Kinsey, B., K. Burger and J.W. Gunning (1998), Coping with drought in Zimbabwe: Survey evidence on responses of rural households to risk, *World Development* 1, 89–110

Lancaster, T. (1990), *The Econometric Analysis of Transition Data*, Cambridge University Press, Cambridge.

Ridder, G. (1984), The distribution of single-spell duration data, in G.R. Neumann and N. Westergård-Nielsen (eds.), *Studies in Labor Market Analysis*, Springer-Verlag, Berlin.

Rosenzweig, M.R. (1988), Risk, implicit contracts and the family in rural areas of low income countries, *Economic Journal* 98, 1148–1170.

Rosenzweig, M.R. (2001), Savings behaviour in low-income countries, *Oxford Review of Economic Policy* 17, 40–54.

Rosenzweig, M.R. and O. Stark (1989), Consumption smoothing, migration, and marriage: evidence from rural India, *Journal of Political Economy* 97, 905–926.

Rosenzweig, M.R. and K.I. Wolpin (1993), Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: investment in bullocks in India, *Journal of Political Economy* 101, 223–244.

Scoones, I. (1995), Investigating difference: Applications of wealth ranking and household survey approaches among farming households in southern Zimbabwe, *Development and Change* 26, 67–88.

Scoones, I., C. Chibudu, S. Chikura, P. Jeranyama, D. Machaka, W. Machanja, B. Mavedzenge, B. Mombeshora, M. Mudhara, C. Mudziwo, F. Murimbarimba and B. Zirereza (1996), *Hazards and Opportunities, Farming Livelihoods in Dryland Africa: Lessons from Zimbabwe*, Zed Books Ltd., London and New Jersey.

Stern, S. (1997), Simulation-based estimation, *Journal of Economic Literature* 35, 2006-2039.

Tsodzo, T.K.M. (1992), Cattle are our bank, in C. Kileff and P. Kileff (eds.), *Shona customs, essays by African writers*, Mambo Press, Gweru, Zimbabwe.

A Parameterization of the theoretical model

For the simulation of our theoretical model, we used the following specification of the model. The planning horizon T of a household equals 14 years. This can be interpreted as the period that a household with unmarried daughters can exist, i.e. the period a family can decide on whether or not to marry off a daughter. The production function of the household $q_t = f(B_t, M_t, R_t,)$ follows a Cobb-Douglas specification:

$$q_t = I(B_t \geq 2)0.5B_t^{0.5}(M_t + 4)^{0.5}R_t^2$$

Because M_t denotes the number of daughters, we take total labor input to be equal to $M_t + 4$, representing the parents and other family members (sons) involved in production. The stochastic variable representing rainfall R_t is uniformly distributed on the interval [0.6,1].

We take the instant utility function to be of the CRRA type and the household's discount rate is 0.2, so that lifetime utility equals

$$U_t = \sum_{\tau=t}^{14}(1 + 0.2)^{t-\tau}\frac{1}{1 - 0.5}c_t^{1-0.5}$$

The depreciation rate of cattle is set to 0.95. We have used two specification for the amount of bride wealth. In the first specification the amount of bride wealth does not vary over time and equals 3 head of cattle. In the second specification the amount of bride wealth depends on the rainfall in the previous year, in particular $p_t = 2 + 5(R_{t-1} - 0.6)$. Finally, the idiosyncratic shock is normally distributed with mean 0 and standard deviation 0.5.

In the simulation study we used polynomials to approximate $U_t(B_t, M_t)$. At each point in time t, for each $M_t = 0, 1, \ldots$ we used a fourth order polynomial in B_t to approximate $U_t(B_t, M_t)$. Both higher and lower order polynomials gave a worse fit for extreme values of B_t and M_t. For the model specification where the amount of bride wealth depends on rainfall in the previous period, R_{t-1} also is a state variable. Therefore, we had to approximate $U_t(B_t, M_t, R_{t-1})$. We used for each t and each $M_t = 0, 1, \ldots$ a polynomial of order 4 in B_t, of order 3 in R_{t-1} and with 1 interaction term between B_t and R_t.

We have done sensitivity analyses with respect to the parameterization. Increasing the variance of the idiosyncratic (wealth) shocks shifts the border between the $m_t = 0$ and the $m_t = 1$ areas to the left, increased uncertainty leads to more marriages at a given livestock wealth.

B Estimating the marriage rate including idiosyncratic wealth shocks as regressors

In this appendix we provide the details of estimating the marriage rate that includes a fixed household component for livestock wealth and a component that describes idiosyncratic shocks in the household's livestock wealth. The household's livestock wealth accumulates according

$$B_{h,t} = \beta_0 + \beta_1 B_{h,t-1} + \beta_2 m_{h,t} + \beta_3 S_{h,t-1} + \beta_4 R_{t-1} + z_h \beta_5 + \eta_h + \varepsilon_{h,t},$$

where η_h is an unobserved household specific wealth component and $\varepsilon_{h,t}$ are random shocks. We assume that both η_h and $\varepsilon_{h,t}$ follow a normal distribution with mean zero and variance σ_η^2 and σ_ε^2 respectively.

The household specific wealth component η_h is not independent of $B_{h,t-1}$. To get rid of η_h, we take first differences,

$$\Delta B_{h,t} = \beta_1 \Delta B_{h,t-1} + \beta_2 \Delta m_{h,t} + \beta_3 \Delta S_{h,t-1} + \beta_4 \Delta R_{t-1} + \Delta\varepsilon_{h,t}$$

However, the new regressor $\Delta B_{h,t-1}$ obtained after the transformation is correlated with the error term $\Delta\varepsilon_{h,t}$ (as $B_{h,t-1}$ depends on $\varepsilon_{h,t-1}$). Also marriage $m_{h,t}$ might depend on shocks in household's livestock wealth one year earlier, which suggests that $m_{h,t}$ can be correlated with $\varepsilon_{h,t-1}$. Therefore, we will use two-stage least squares (2SLS) to estimate the model, where in the first stage we estimate

$$\begin{aligned}
\Delta B_{h,t-1} = {} & \gamma_0 + \gamma_1 B_{h,t-2} + \gamma_2 B_{h,t-3} + \gamma_3 m_{h,t-1} + \gamma_4 \Delta S_{h,t-1} + \gamma_5 \Delta S_{h,t-2} \\
& + \gamma_6 \Delta R_{t-1} + \gamma_7 \Delta R_{t-2} + u_{h,t}^1 \\
\Delta m_{h,t} = {} & \delta_0 + \delta_1 B_{h,t-2} + \delta_2 B_{h,t-3} + \delta_3 m_{h,t-1} + \delta_4 \Delta S_{h,t-1} + \delta_5 \Delta S_{h,t-2} \\
& + \delta_6 \Delta R_{t-1} + \delta_7 \Delta R_{t-2} + u_{h,t}^2
\end{aligned}$$

This 2SLS procedure provides consistent estimators $\hat{\beta}_1$, $\hat{\beta}_2$ and $\hat{\beta}_3$ (as $H \to \infty$).[11] As an estimator for σ_ε^2, we use

$$\hat{\sigma}_\varepsilon^2 = \frac{1}{H} \sum_{h=1}^{H} \frac{1}{T_h - 1} \sum_{t=1}^{T_h} \left(\hat{u}_{h,t} - \frac{1}{T_h} \sum_{t=1}^{T_h} \hat{u}_{h,t} \right)^2$$

where

$$\hat{u}_{h,t} = B_{h,t} - \hat{\beta}_1 B_{h,t-1} - \hat{\beta}_2 m_{h,t} - \hat{\beta}_3 S_{h,t-1} - \hat{\beta}_4 R_{t-1}$$

[11] We have performed a Sargan-test to test the specification of our model and the validity of the set of instrumental variables. The value of the test statistics equals 4.51. Since it follows a χ^2-distribution with 3 degrees of freedom, we cannot reject that the model is misspecified or that the instrumental variables are invalid.

When computing the standard errors for $\hat{\beta}_1$, $\hat{\beta}_2$, $\hat{\beta}_3$ and $\hat{\beta}_4$ we have corrected for correlation between $\Delta\varepsilon_{h,t}$ and $\Delta\varepsilon_{h,t-1}$, i.e. $cov(\Delta\varepsilon_{h,t-1}, \Delta\varepsilon_{h,t}) = -\sigma_\varepsilon^2$ and $var(\Delta\varepsilon_{h,t}) = 2\sigma_\varepsilon^2$. The estimation results are given in Table 8.

Next, we estimate the parameters β_0 and β_5. Therefore, we use the regression

$$\frac{1}{T_h}\sum_{t=1}^{T_h} \hat{u}_{h,t} = \beta_0 + z_h\beta_5 + e_h$$

where it can be shown that

$$\begin{aligned} e_h = {} & \eta_h + \frac{1}{T_h}\sum_{t=1}^{T_h}\varepsilon_{h,t} + \frac{1}{T_h}\sum_{t=1}^{T_h}(\beta_1 - \hat{\beta}_1)B_{h,t-1} + (\beta_2 - \hat{\beta}_2)m_{h,t} \\ & + (\beta_3 - \hat{\beta}_3)S_{h,t-1} + (\beta_4 - \hat{\beta}_4)R_{t-1} \end{aligned}$$

We can use OLS to estimate the parameters β_0 and β_5, but when computing standard errors we should take into account that the disturbances e_h are all correlated with each other and that they suffer from heteroskedasticity. The estimation results are reported in Table 9.

As will become clear below, we need to know the complete variance-covariance matrix of $\left[\hat{\beta}_0; \hat{\beta}_5'\right]'$ and $\left[\hat{\beta}_1; \hat{\beta}_2; \hat{\beta}_3; \hat{\beta}_4\right]'$. This implies that we also should estimate the covariance matrix of the estimators $\left[\hat{\beta}_0; \hat{\beta}_5'\right]'$ with the estimators $\left[\hat{\beta}_1; \hat{\beta}_2; \hat{\beta}_3; \hat{\beta}_4\right]'$. We know that

$$\begin{bmatrix} \hat{\beta}_0 - \beta_0 \\ \hat{\beta}_5 - \beta_5 \end{bmatrix} = \left([\iota; Z]'\,[\iota; Z]\right)^{-1}[\iota; Z]' \begin{bmatrix} e_1 \\ \vdots \\ e_H \end{bmatrix}$$

where ι is a vector containing 1s and Z is a matrix with the vectors z_h. As we know how e_h depends on $\hat{\beta}_1$, $\hat{\beta}_2$, $\hat{\beta}_3$, and $\hat{\beta}_4$, we get an expression for the covariance matrix between $\left[\hat{\beta}_0; \hat{\beta}_5'\right]'$ and $\left[\hat{\beta}_1; \hat{\beta}_2; \hat{\beta}_3; \hat{\beta}_4\right]'$. Let the estimated variance-covariance matrix of the estimators $\left[\hat{\beta}_0; \hat{\beta}_1; \hat{\beta}_2; \hat{\beta}_3; \hat{\beta}_4'; \hat{\beta}_5\right]'$ be given by $\hat{\Omega}$.

The marriage rate is specified at the level of daughters instead of households. Woman $i = 1, \ldots, N$ lives in a household with household specific effect η_i and yearly shocks are $\varepsilon_{i,1}, \ldots, \varepsilon_{i,T}$. However, η_i and $\varepsilon_{i,\tau}$ are unobserved, instead we observe the estimated residual

$$\hat{v}_{h,t} = w_{h,t} - \hat{\beta}_0 - \hat{\beta}_1 w_{h,t-1} - \hat{\beta}_2 m_{h,t} - \hat{\beta}_3 x_{h,t-1} - \hat{\beta}_4 r_{t-1} - z_h\hat{\beta}_5$$

We should therefore optimize the loglikelihood function

$$\log\left(\int\prod_{i=1}^{N}\Pr(T\in[\tau_i^*,\tau_i^*+1)|x_{\tau_{0,i}+t_0},\ldots,x_{\tau_i^*},\eta_i,\varepsilon_{i,\tau_{0,i}+t_0},\ldots,\varepsilon_{i,\tau_i^*})f(\eta,\varepsilon|\hat{v})\ \mathrm{d}(\eta,\varepsilon)\right)$$

where η is a vector containing all household specific effects, ε is a matrix containing for all households all yearly shocks and $\hat{v}$ is a matrix containing the estimated residuals $\hat{v}_{h,t}$.

The remaining problem is to specify the density function $f(\eta,\varepsilon|\hat{v})$. We rewrite this density function by conditioning on a matrix v containing the elements $v_{h,t}=\eta_h+\varepsilon_{h,t}$, as

$$f(\eta,\varepsilon|\hat{v})=\int f(\eta,\varepsilon|v,\hat{v})f(v|\hat{v})dv$$

It is clear that if we know v, then $\hat{v}$ is not informative about η and ε, thus

$$f(\eta,\varepsilon|v,\hat{v})=f(\eta,\varepsilon|v)$$

This density function can be written as

$$\begin{aligned}
f(\eta,\varepsilon|v) &= \prod_{h=1}^{H} f(\eta_h,\varepsilon_{h,1}\ldots,\varepsilon_{h,T_h}|v_{h,1},\ldots,v_{h,T_h})\\
&\propto \prod_{h=1}^{H} f(v_{h,1},\ldots,v_{h,T_h}|\eta_h,\varepsilon_{h,1},\ldots,\varepsilon_{h,T_h})f(\eta_h,\varepsilon_{h,1},\ldots,\varepsilon_{h,T_h})\\
&= \prod_{h=1}^{H}\phi(\eta_h)\prod_{t=1}^{T_h} I(\varepsilon_{h,t}=v_{h,t}-\eta_h)\phi(\varepsilon_{h,t})
\end{aligned}$$

where $I(\cdot)$ is the indicator function. In the last step we used that both η_i and $\varepsilon_{i,t}$ follow normal distributions (as was assumed earlier).

Next we have to focus on $f(v|\hat{v})$. Note that

$$\begin{aligned}
v_{h,t} =&\ B_{h,t}-\beta_0-\beta_1 B_{h,t-1}-\beta_2 m_{h,t}-\beta_3 S_{h,t-1}-\beta_4 R_{t-1}-z_h\beta_5\\
=&\ \hat{\beta}_0+\hat{\beta}_1 B_{h,t-1}+\hat{\beta}_2 m_{h,t}+\hat{\beta}_3 S_{h,t-1}+\hat{\beta}_4 R_{t-1}+z_h\hat{\beta}_5+\hat{v}_{h,t}\\
&-\beta_0-\beta_1 B_{h,t-1}-\beta_2 m_{h,t}-\beta_3 S_{h,t-1}-\beta_4 R_{t-1}-z_h\beta_5\\
=&\ (\hat{\beta}_0-\beta_0)+(\hat{\beta}_1-\beta_1)B_{h,t-1}+(\hat{\beta}_2-\beta_2)m_{h,t}\\
&+(\hat{\beta}_3-\beta_3)S_{h,t-1}+R_{t-1}(\hat{\beta}_4-\beta_4)+z_h(\hat{\beta}_5-\beta_5)+\hat{v}_{h,t}
\end{aligned}$$

This implies that the vectorized matrix v is asymptotically normal distributed with mean the vectorized matrix $\hat{v}$ and variance-covariance matrix $X\hat{\Omega}X'$, where X is a matrix that contains rows $[1;B_{h,t-1};m_{h,t};S_{h,t-1};R_{t-1};z_h]$.

To optimize the loglikelihood function given above we use simulated maximum likelihood estimation (e.g. Stern, 1997). We draw 1000 times from the distribution $f(\eta, \varepsilon|\hat{v})$. For each draw $j = 1, \ldots, 1000$ we follow procedure: (i) given the values $\hat{v}$ we generate a matrix v_j, (ii) we generate a vector η_j with household specific effects from a normal distribution with mean 0 and variance $\hat{\sigma}^2_\eta$, (iii) we compute the matrix of shocks $\varepsilon_j = v_j - \eta_j$, (iv) we compute the likelihood contribution and we weight this by $p_j = \phi(\varepsilon_j)$, (v) To obtain the likelihood contribution of an individual we sum the weighted individual likelihood contributions and finally we optimize the sum of the logarithm of the individual likelihood contributions.

Year	Sample size at beginning of year	Number of marriages	Average age of marriage	Rainfall in previous season local	Zimbabwe
Mpfurudzi					
1994	215	34	20.5	0.69	0.52
1995	209	29	19.9	0.52	0.42
1996	202	26	19.3	0.77	0.70
1997	182	25	19.4	1.25	0.75
1998	180	17	18.4	0.70	0.53
1999	169	25	18.9	0.99	0.78
Mutanda					
1994	84	9	21.1	0.72	0.52
1995	80	7	23.3	0.58	0.42
1996	86	10	18.4	0.93	0.70
1997	76	11	19.0	0.97	0.75
1998	63	3	18.3	0.70	0.53
1999	58	3	19.0	1.27	0.78
Sengezi					
1994	60	7	20.0	0.52	0.52
1995	60	9	18.1	0.47	0.42
1996	55	9	19.9	0.90	0.70
1997	51	5	20.8	0.96	0.75
1998	44	1	16.0	0.72	0.53
1999	39	3	17.7	0.95	0.78
Total		233			

Explanatory note: The quantity of rainfall is measured in meters per year and collected by the Department of Meteorological Services in Zimbabwe.

Table 1: Some annual statistics of the sample of unmarried women in the age interval between 15 and 30.

	Head of cattle		
	0-2	3-4	5+
1994	20.2	21.4	22.0
1995	19.1	22.4	21.4
1996	20.7	20.8	19.8
1997	20.4	19.3	21.0
1998	18.9	19.5	19.8
1999	19.2	17.5	19.7

Table 2: Average age at which a daughter gets married stratified by the year of marriage and the herd size (cows, bulls, trained oxen and heifers) of the household.

Variable	**Average**
Region	
Mpfurudzi (%)	63
Mutanda (%)	21
Sengezi (%)	16
Individual characteristics	
African faith (%)	17
Masowe faith (%)	6
Household characteristics	
Missing (%)	10
Household size (persons)	12
Father absent (%)	17
Mother absent (%)	4
Age father (years)	53
Age mother (years)	45
Years of education father	5.1
Years of eduction mother	4.1
Number of observations	691

Explanatory note: Age of the father and the mother are measured at the moment the daughter was 15 years of age. Household size is measured at the moment the women first appeared in the stock sample.

Table 3: Stock sample characteristics.

Year	**Sample size at beginning of year**	**Number of marriages**	**Average age of marriage**
1994	62	0	–
1995	122	1	16.0
1996	175	8	16.3
1997	204	13	17.1
1998	219	12	17.3
1999	221	23	18.6
Total		57	

Table 4: Some annual statistics of the flow sample of unmarried women.

Year	**Livestock wealth**	
	Not married	**Married**
1994	9.7	–
1995	11.3	0.5
1996	12.0	6.6
1997	12.7	10.7
1998	13.6	9.1
1999	13.4	14.7

Explanatory note: In 1995, the prices (in Zimbabwean dollars) of cattle were: Cows 1200; Heifer 1000; Trained ox 1800; Young ox 1000; Bull 1500; and Goat 85.

Table 5: Average livestock wealth (in its real value in 1995) owned by the household, stratified by the women getting married in a particular year or not.

	Marriage hazard	
Intercept		
v	-5.38	(0.99)
Baseline hazard (Age)		
λ_{15-16}	0	
λ_{17-18}	1.04	(0.40)
λ_{19-20}	2.02	(0.52)
Region		
Mpfurudzi	0	
Mutanda	-0.26	(0.39)
Sengezi	-0.50	(0.45)
Faith		
Christian	0	
African	-0.78	(0.67)
Masowe faith	-0.40	(0.61)
Rainfall (in meters)		
	0.64	(0.77)
Individual and household characteristics		
Oldest unmarried daughter	0.51	(0.35)
Missing	1.97	(0.56)
Household size	0.083	(0.027)
Parent absent	0.41	(0.39)
Livestock wealth shock ($\varepsilon_{i,t}$ in cows)	-0.10	(0.049)
Livestock wealth level (η_i in cows)	-0.025	(0.026)
$\log \mathcal{L}$	-185.76	
N	333	

Explanatory note: Standard errors in parentheses.

Table 6: Estimation results for the marriage rate.

	Bride wealth payments			
	Short term		Long term	
Intercept	1.02	(3.10)	1.73	(1.35)
Age	−1.14	(0.090)	0.024	(0.051)
Rainfall	−1.85	(3.11)	−1.21	(1.51)
Oldest daughter	0.72	(0.62)	−0.14	(0.41)
Livestock wealth (in cows)	−0.043	(0.035)	0.027	(0.019)
σ	0.93	(0.037)	2.08	(0.097)
N	424		174	

Explanatory note: Standard errors in parentheses.

Table 7: Estimation results of the censored regression (tobit) model for the amount of bride wealth (in cows) received in the year of marriage (short term) and received in total (long term).

	$\Delta w_{h,t}$					
$\Delta w_{h,t-1}$	β_1	0.053	(0.086)			
$\Delta m_{h,t}$	β_2	0.81	(0.64)			
$\Delta s_{h,t-1}$	β_3	−0.0061	(0.098)			
$\Delta r_{h,t-1}$	β_4	0.73	(0.64)			
	σ_ε^2	21.4				
	$\Delta w_{h,t-1}$			$\Delta m_{h,t}$		
Intercept	γ_0	0.80	(0.28)	δ_0	0.12	(0.019)
$w_{h,t-2}$	γ_1	−0.43	(0.028)	δ_1	−0.00064	(0.0019)
$w_{h,t-3}$	γ_2	0.42	(0.031)	δ_2	0.00025	(0.0020)
$m_{h,t-1}$	γ_3	0.70	(0.48)	δ_3	−0.92	(0.032)
$\Delta s_{h,t-1}$	γ_4	0.091	(0.073)	δ_4	0.0086	(0.0048)
$\Delta s_{h,t-2}$	γ_5	0.14	(0.063)	δ_4	0.011	(0.0041)
$\Delta r_{h,t-1}$	γ_6	0.19	(0.55)	δ_4	−0.0032	(0.036)
$\Delta r_{h,t-2}$	γ_7	0.36	(0.57)	δ_4	0.047	(0.037)
R^2	0.20			0.48		
$F_{7,998}$	34.7			128.91		
H	290					
$\sum_{h=1}^{H}(T_h - 1)$	1006					

Explanatory note: (corrected) standard errors in parentheses.

Table 8: Estimation results of 2SLS for β_1, β_2, β_3, and β_4.

Intercept	β_0	10.53	(2.78)
Mutunda	β_5	−2.09	(1.31)
Sengezi	β_5	0.61	(1.35)
Parent absent	β_5	−1.67	(1.25)
African faith	β_5	2.05	(1.46)
Masowe faith	β_5	−0.058	(2.19)
	σ_η^2	69.8	
H		290	

Explanatory note: (corrected) standard errors in parentheses.

Table 9: Estimation results of OLS for β_0 and β_5.

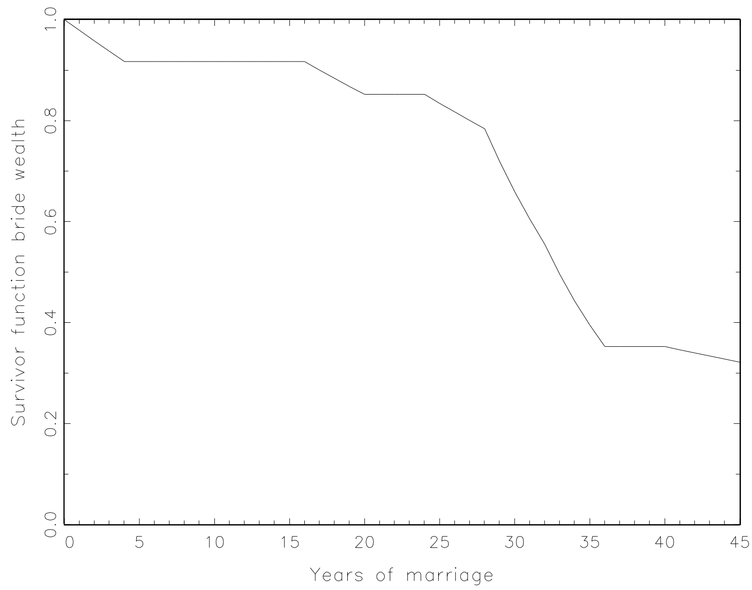

Figure 1: The fraction of the marriages where all bride wealth payments are made at a given number of years of marriage. This figure is based on a supplement held in 1995 of the data used in this paper.

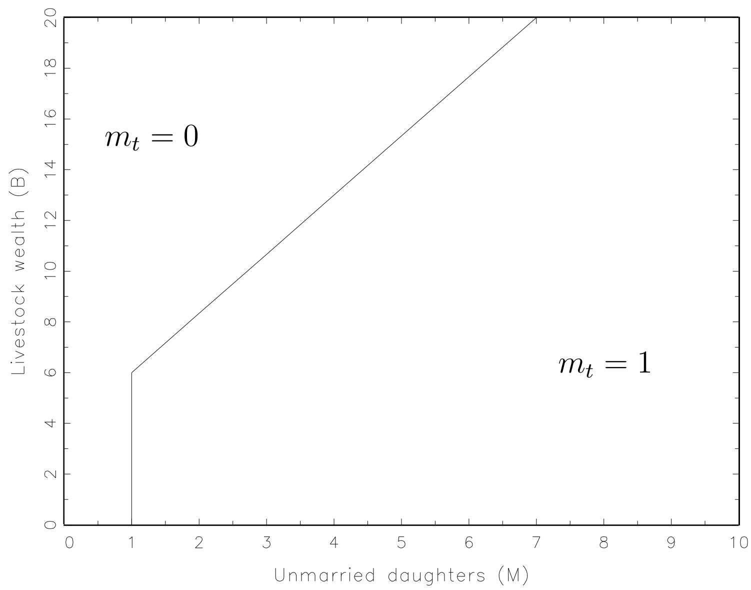

Figure 2: The marriage decision of households with M_t unmarried daughters and B_t livestock wealth. The area $m_t = 1$ describes where it is optimal for the household to marry off a daughter. The amount of bride wealth is independent of the amount of rainfall.

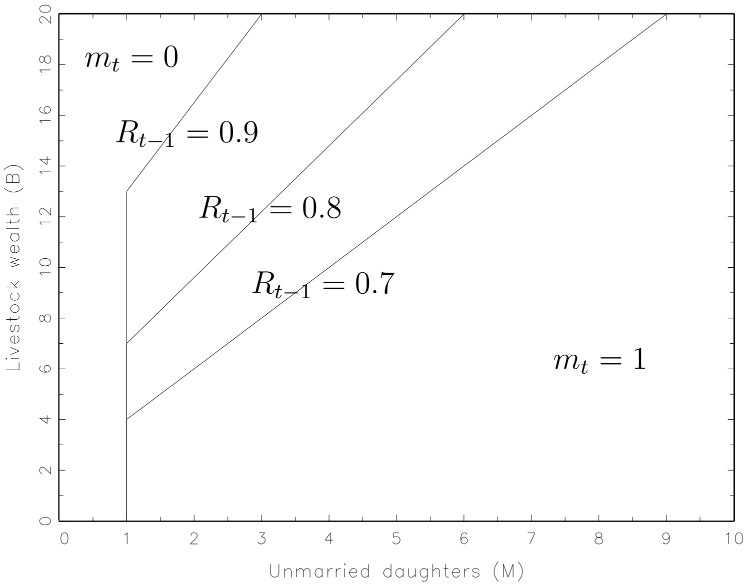

Figure 3: The marriage decision of households with M_t unmarried daughters and B_t livestock wealth. The area $m_t = 1$ describes where it is optimal for the household to marry off a daughter. The amount of bride wealth is decreasing in the amount of rainfall.

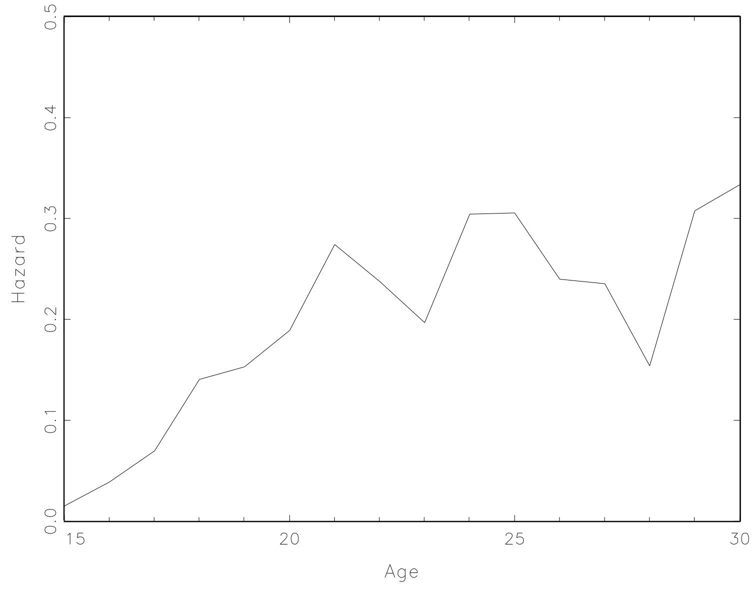

Figure 4: The empirical marriage rate, i.e. the probability of getting married at a given age conditional on still being unmarried when reaching this age.

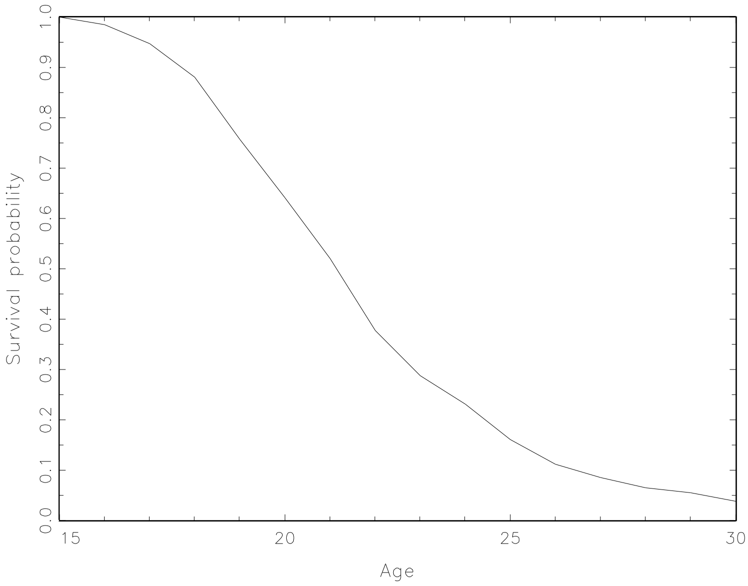

Figure 5: Kaplan-Meier estimate of the survivor function. This shows the percentage of women still unmarried at a given age.