A Theory of Child Marriage

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Abstract

The practice of early marriage for women remains prevalent in developing countries around the world today, and is associated with various health risks, including infant mortality and maternal mortality as a consequence of early pregnancy. This paper develops a dynamic model of a marriage market to explore whether a norm of early marriage for women can prevail in the absence of any intrinsic preference for young brides. We show that if a certain desirable female attribute, relevant for the gains from marriage, is only noisily observed before a marriage is contracted, then its prevalence declines in each age cohort with time spent on the marriage market; thus, age can signal poorer quality and require higher marriage payments. In this situation, we show that interventions that increase the opportunity cost of early marriage – such as increased access to secondary schooling or adolescent development programmes – can trigger a virtuous cycle of marriage postponement even if the original intervention is not sufficient, in itself, to persuade all women to turn down offers of early marriage.

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1 Introduction

Child marriage and the marriage of young adolescents remains prevalent in many parts of the world despite repeated efforts by national governments and international development agencies to discourage and end the practice. According to the State of World Population Report 2005, 48 per cent of women in Southern Asia, and 42 per cent of women in Africa in the age group 15-24 years had married before reaching the age of 18 (UNFPA 2005). Child marriage is likely to lead to early pregnancy and associated health risks for the mother and the child; and force the marriage partners, especially the bride, to terminate schooling prematurely. (Unicef 2001; Unicef 2005).

In recent years, international organisations and NGO's have renewed efforts to discourage child marriage, through interventions that raise awareness about its negative consequences, that provide parents incentives to postpone marriage for their children, and that provide adolescents new opportunities to acquire skills and alternatives to a traditional path of early marriage and early motherhood. Notable examples include Brac's Adolescent Development Programme in Bangladesh, which provides livelihood training courses, education to raise awareness on social and health issues, and clubs to foster socialisation and discussion among peers; and the Berhane Hewan project in Amhara, Ethiopia, a joint initiative between the New York based Population Council and the Amhara regional government, which uses community dialogue, and simple incentives involving school supplies to encourage delayed marriage and longer stay in school for girls. The World Bank, the UK Department for International Development, and the Nike Foundation are providing support to a number of similar projects around the world.

While parents and adolescents respond to incentives for delaying marriage, doing so appears to carry a penalty on the marriage market: they are required to make higher marriage payments, a higher dowry, at the time of marriage (Amin and Bhajracharya, 2011; Field and Ambrus, 2008).

In his well-known study of marriage patterns across the world, Jack Goody has highlighted a number of reasons why young brides are preferred in traditional societies: they have a longer period of fertility before them; and they are more likely to be obedient and docile, necessary qualities to learn and accept the rules and ways of her new household (Goody, 1990). Relatedly, Dixon (1971) attributed the historic practice of early marriage in China, India, Japan and Arabia to the prevalence of 'clans and lineages' which gave economic and social support to newly married couples, as well as pressures to produce children for strengthening and sustaining the clan. By contrast, the traditional emphasis on individual responsibility in 'Western family systems' meant that newly married couples were expected to be able to provide for themselves and their children, which 'necessarily causes marital delays while the potential bride and groom acquire the needed skills, resources and maturity to manage an independent household' (Dixon 1971).

However, these explanations of early marriage do not, in themselves, explain why the age of marriage for women has remained low in some societies despite declines in fertility, and evolution towards a nuclear household model. Questions of this nature require an understanding – not just about the preferences, opportunities and constraints faced by parents and households that practise child marriage – but about the 'marriage market equilibrium', the conditions under which the practice of child marriage may be collectively sustained in a society. Similarly, the eventual consequences of any large-scale programme which aim to discourage child marriage will depend – not only on how individual households respond to these incentives – but on the equilibrium effects of these interventions.

In this paper, we develop a dynamic model of a marriage market to obtain insights about the practice of child marriage. We show that even if an inherent preference for young brides is absent among potential grooms and their families, a scenario where they all seek young brides is a stable equilibrium; and under certain conditions, the unique equilibrium.

The equilibrium preference for young brides is driven by a kind of informational asymmetry. We assume that a certain attribute considered desirable in a bride is unobservable except for a noisy signal received when a match has been arranged. In equilibrium, the prevalence of this attribute declines in each age cohort with time spent on the marriage market; thus, age of the bride can signal quality. Young potential brides, aware that they will be perceived as being of poorer quality the longer they remain on the marriage market would, therefore, have an incentive to accept an offer of marriage sooner rather than later.

Large-scale interventions of the kind discussed earlier provide adolescent girls with opportunities other than marriage. If these opportunities are sufficiently attractive for at least some adolescent (young) girls to turn down offers of marriage, then this reduces the correlation between the age of a potential bride and her quality. In turn, this would provide other women incentives to turn down offers of marriage, which further reduces the correlation between the age of a potential bride and her quality. Thus, expanding non-marriage related opportunities for adolescents can trigger a virtuous cycle of marriage postponement even if the original intervention is not sufficient, in itself, to persuade all women (and their families) to turn down offers of marriage.

The fact that an intervention targeted at adolescent girls can make it more and more attractive for future cohorts to postpone marriage means that the long-term impact of such interventions on marriage and subsequent life choices may well exceed the immediate impact.

A recent literature on marriage practices around the world has explored the possibility that certain, potentially harmful, practices can be maintained as self-sustaining equilibria. Mackie (1996) applies the concept of Shelling's focal point to explain why the practice of footbinding in China had survived over a thousand years, and how it came to an end very quickly at the beginning of the 20th century. Mackie (2000) and Mackie and LeJeune (2009) applies the same game-theoretic framework to the practice of female circumcision and argues that it may be undergoing a similar transition in West Africa now, at the beginning of the 21st century. In a similar spirit, this paper investigates whether the practice of child marriage can be sustained as a self-sustaining equilibrium in the absence of intrinsic preferences for young brides; and if so, under what conditions could such an equilibrium unravel.

Relatedly, Bidner and Eswaran (2012) provides an explanation for the emergence of the caste system in India that also accounts for a number of marriage-related practices common to the Indian context, including child marriage. They develop a model of production and exchange in which complementarity of skills between the husband and wife in household production gives rise to a preference for endogamy within groups that are engaged in distinct occupations. The practice of child marriage (as well as arranged marriages, etc.) reduce the risk of group members coming into contact with – and mating with – members of other (caste) groups. As the practice of child marriage exists in contexts where caste and caste-like institutions do not prevail – such as muslim communities in South Asia, and in Africa – the phenomenon also calls for other explanatory factors, such as the mechanism provided in this paper.

2 A Model of Marriage Timing

In this section, we develop a dynamic model of a marriage market to explore the conditions under which child marriage may be sustained in equilibrium, and conditions under which the practice may unravel.

The theoretical model presented in this paper follows the literature on dynamic search and matching initiated by Diamond and Maskin (1979). The framework has previously been used to investigate a number of marriage-related phenomena. For example, Bergstrom and Bangoli (1993) develop a matching model to explain the age gap between husbands and wives. Anderson (2007) investigates the effect of population growth on rising dowry prices. Sautmann (2011) provides a characterisation of the marriage payoff functions which would lead to commonly observed marrage age patterns around the world, including positive assortative matching in age and a positive age gap between grooms and brides.

Since our key interest is the question of marriage timing, we make certain simplifying assumptions vis-a-vis the existing literature on marriage markets; assumptions which, we will argue, are reasonable given contemporary marriage patterns in South Asia. In contrast to Sautmann's paper, we abstract away from any intrinsic age-related preferences on the marriage market and focus, instead, on the imperfect observability of the characteristics of potential marriage partners to explain the phenomenon of early marriage.

In *Arguing with the Crocodile*, Sarah White provides a detailed ethnographic account of marriage practices in rural Bangladesh. She notes that it is customary for the groom's family to initiate contact with the bride's family, and that this contact is made through a 'matchmaker' who provides a communication line, and facilitates negotiations, between the two parties (White 1992). She notes that "the different parties manouvre and fight their own corners, aiming to achieve the best bargain they can" which suggests that bargaining is a key element of the negotiation process. Moreover "the many interests involved in the making of a marriage undoubtedly color the evidence given. Mismatches occur not only through lack of information, but also through deliberate deception", which suggests that each party has limited information about the potential match, and that they may choose not to disclose information about their daughter or son that may be regarded as a defect on the marriage market. Therefore, "... attention ... is often focused primarily on the wealth of the household, and the amount of dowry which is demanded or offered" (White 1992).

In line with this description, we model the matching process in the marriage market, as one that is initiated by the potential groom (or his family), via a match-maker, as discussed in the next section. Furthermore, we assume that both the potential bride and groom have unobserved characteristics relevant for the marriage which may be revealed through a 'background check or inferred from observable characteristics such as their age. The marriage transfer is agreed upon through bargaining between the two parties. There is no *remarriage* market; i.e. once a bride and groom are married, they have no possibility of re-entering the marriage market to seek a new partner. And women remain on the marriage market – i.e. are considered eligible for marriage – during a finite number of years. These last two assumptions seem justified given that, in South Asia, the incidence of separation and divorce remains very low (Dommaraju and Jones, 2011) and that most women marry by their late twenties (Mensch, Singh and Casterline, 2005).

2.1 Description of the Marriage Market

The marriage market consists of four types of individuals: 'young' men, 'young' women, 'older' men and 'older' women. The number of individuals of each type at time t are given by $n_{m1}(t)$, $n_{m2}(t)$, $n_{f1}(t)$ and $n_{f2}(t)$ respectively.

Two individuals of the same type are exactly alike in terms of their observable characteristics. Women have an unobservable characteristic which we call 'moral character', which may be either 'good' or 'bad'. Women in the population have 'bad moral character' with probability $\varepsilon_f \in (0,1)$, a constant that is exogenously given.

The utility from marriage depends on the marital transfers involved and the moral character of the partners. If a marriage between a man and a woman involves a net pre-marital transfer τ from the bride to the groom, and the probability that the bride has 'bad moral character' is ε_f, then we represent the utility to the groom by the function $u_m(\tau, \varepsilon_f)$. Similarly, if the probability that the groom has 'bad moral character' is ε_m, then the utility to the bride is given by $u_f(\tau, \varepsilon_m)$. Note that men are assumed not to have any intrinsic preference between 'young' and 'older' brides; and women are assumed not to have any intrinsic preference between 'young' and 'older' grooms.

The matching process between prospective grooms and prospective brides operates according to the following sequence of events:

1. Men state a preference as to whether they would like to be matched with a 'young' woman or an 'older' woman. A search is then initiated by the matchmaker.

2. The probability that the matchmaker finds a match for a man seeking a young bride is given by the function $\mu\left(\frac{n_{f1}}{\theta n_m}\right)$ where θ is the proportion of all men who state a preference for a young bride at stage 1, and $n_m = n_{m1} + n_{m2}$. Similarly, the probability that the matchmaker finds a match for a man seeking an older bride is given by $\mu\left(\frac{n_{f2}}{(1-\theta) n_m}\right)$.

3. If a match has been found, the prospective bride and groom decide whether they will enter into a discussion regarding marriage.

4. If marriage discussions are initiated, a 'background check' is performed on the prospective bride. For the sake of simplicity, we assume no such technology is available to perform a 'background check' on the prospective groom.

5. The background check can have two possible outcomes. It may reveal nothing or it may reveal that the prospective bride has 'bad moral character'. If a prospective bride has 'bad moral character', then the background check reveals her true character with probability $\pi \in (0,1)$.

6. The two sides decide whether the marriage should go ahead. If they decide the marriage will not take place, they remain single for the remainder of the period. The utility levels obtained from being single during one period are denoted by $\underline{u}_m$ and $\underline{u}_f$ for men and women respectively.

7. If they decide to marry, then a bargaining process determines the level of pre-marital transfers, if any. Specifically, if the probability that the prospective groom and bride have 'bad' moral character are given by ε_m and ε_f respectively, and the utility to the man and woman from their outside options are v_m and v_f respectively, then the net marital transfers (from the bride to the groom) agreed upon through bargaining is given by $\tau = \xi(v_m, v_f, \varepsilon_m, \varepsilon_f)$.

When any individual marries, he or she leaves the marriage market with no possibility of re-entry. Young women and young men who fail to/choose not to marry in a particular period, re-enter the marriage market as, respectively, older women and older men in the next period. Older women and older men who fail to/choose not to marry in a particular period must remain single thereafter (i.e. they leave the marriage market). In each period, a new cohort of y young women and y young men reach marriageable age. To simplify the dynamics, we further assume that young men prefer not to marry (perhaps because they do not have the means to support a family till they become 'older').

We make the following assumptions about the functions $u_m(.)$, $u_f(.)$, $\mu(.)$ and $\xi(.)$.

Assumption 1 $u_m(\tau, \varepsilon_f)$ *is strictly increasing in* τ *and strictly decreasing in* ε_f.

Assumption 2 $u_f(\tau, \varepsilon_m)$ *is strictly decreasing in* τ *and strictly decreasing in* ε_m.

Assumption 3 $\mu(.)$ *is strictly increasing with a range of* $[0,1]$ *and* $\mu(0) = 0$.

Assumption 4 $\theta\mu\left(\frac{x}{\theta}\right)$ *is increasing in* θ *for all* x.

Assumption 5 $\xi(v_m, v_f, \varepsilon_m, \varepsilon_f)$ *is (weakly) increasing in* v_m*, decreasing in* v_f*, decreasing in* ε_m *and increasing in* ε_f.

Assumption 6 $\underline{u}_m + \underline{u}_f > u_m(\tau, 1) + u_f(\tau, \varepsilon_m)$ *and* $\underline{u}_m + \underline{u}_f > u_m(\tau, \varepsilon_f) + u_f(\tau, 1)$ *for all* τ.

Assumption 7 $\underline{u}_m < u_m(\tau, \varepsilon_f)$ *and* $\underline{u}_f < u_f(\tau, \varepsilon_m)$ *for some* τ.

Assumption 8 $u_m(\xi(v_m, v_f, \varepsilon_m, \varepsilon_f), \varepsilon_f)$ *is decreasing in* ε_f *and* $u_f(\xi(v_m, v_f, \varepsilon_m, \varepsilon_f), \varepsilon_m)$ *is decreasing in* ε_m.

Assumption 6 implies that if either the prospective bride or groom is found to have bad moral character (with no new information obtained regarding the other party), then there is no level of pre-marital transfers such that both parties would prefer marriage to singlehood). By contrast, Assumption 7 implies that if no new information is obtained regarding the prospective bride or groom, then there exits a level of pre-marital transfers such that both parties would prefer marriage to singlehood.

Assumption 4 is a restriction imposed on the function $\mu(.)$ which ensures that as the proportion of men who state a preference for a particular type of bride (either 'young' or 'older') increases, so does the *number* of men who are matched with that type of bride.

Assumption 8 implies that as the reputation of a prospective partner improves, so does the utility from marrying him or her, even after taking into account that a partner with a better reputation will require a higher net marriage transfer.

Future utility is discounted by a factor $\beta \in (0,1)$ per period. For the sake of simplicity, we assume that men and women are infinitely lived (although they remain on the marriage market for only a finite number of periods).

We denote by λ_1 and λ_2, respectively, the probability of finding a match for young women and older women on the marriage market. By construction, we must have

$$\lambda_1 n_{f1} = \mu\left(\frac{n_{f1}}{\theta n_m}\right)\theta n_m \quad (1)$$

$$\lambda_2 n_{f2} = \mu\left(\frac{n_{f2}}{(1-\theta)\, n_m}\right)(1-\theta)\, n_m \quad (2)$$

2.2 Solving the Model

Whether men prefer young brides or older brides will depend on the 'reputation' (i.e. the probability of having bad moral characer) of each cohort.

Background Checks: Let us denote by ε_{f1} and ε_{f2} the probability of 'bad moral character' among young and older women respectively *before* any background check has been performed; and, by $\hat{\varepsilon}_{f1}$ and $\hat{\varepsilon}_{f2}$, the probability of 'bad moral character' among young and older women respectively *after* a background check has been performed and the check has revealed nothing.

As there is no information available on the moral character of young women when they first enter the marriage market, we must have $\varepsilon_{f1} = \varepsilon_f$. For older women, the probability of bad moral character (before a background check has been performed) depends on the likelihood that they were matched with a man when young. Specifically, using Bayes' rule, we obtain

$$\begin{aligned}\varepsilon_{f2} &= \Pr(\text{bad}|\text{older}) \\ &= \frac{\Pr(\text{older}|\text{bad})\Pr(\text{bad})}{\Pr(\text{older})} \\ &= \frac{[(1-\lambda_1)+\lambda_1\pi]\,\varepsilon_f}{(1-\lambda_1)+\lambda_1\pi\varepsilon_f} \quad (3)\end{aligned}$$

From (3), it is evident that if $\lambda_1 > 0$ and $\varepsilon_f > 0$, then $\varepsilon_{f2} > \frac{[(1-\lambda_1)+\lambda_1\pi]\varepsilon_f}{(1-\lambda_1)+\lambda_1\pi} = \varepsilon_f$. Therefore, if there are some women who are getting married when young, the probability of bad moral character is higher among older woman than among young women.

Given that a background check detects 'bad moral character' only with some probability $\pi < 1$, a woman for whom such a check has revealed nothing, will still be assigned a positive probability of having a bad moral character. We can determine this probability for young and older women using Bayes' rule as follows:

$$
\begin{aligned}
\hat{\varepsilon}_{f1} &= \Pr(\text{bad}|\text{young+nothing}) \\
&= \frac{\Pr(\text{young+nothing}|\text{bad})\Pr(\text{bad})}{\Pr(\text{young+nothing})} \\
&= \frac{(1-\pi)\,\varepsilon_{f1}}{(1-\varepsilon_{f1})+(1-\pi)\,\varepsilon_{f1}} \\
&< \frac{(1-\pi)\,\varepsilon_{f1}}{(1-\pi)(1-\varepsilon_{f1})+(1-\pi)\,\varepsilon_{f1}} \\
&< \varepsilon_{f1}
\end{aligned}
\tag{4}
$$

$$
\begin{aligned}
\hat{\varepsilon}_{f2} &= \Pr(\text{bad}|\text{mature+nothing}) \\
&= \frac{\Pr(\text{mature+nothing}|\text{bad})\Pr(\text{bad})}{\Pr(\text{mature+nothing})} \\
&= \frac{(1-\pi)\,\varepsilon_{f2}}{(1-\varepsilon_{f2})+(1-\pi)\,\varepsilon_{f2}} \\
&< \frac{(1-\pi)\,\varepsilon_{f2}}{(1-\pi)(1-\varepsilon_{f2})+(1-\pi)\,\varepsilon_{f2}} \\
&< \varepsilon_{f2}
\end{aligned}
\tag{5}
$$

So, when a background check on a woman reveals nothing, the probability that she has bad moral character declines but remains positive, in case of both young women and older women.

In summary, we have established the following results.

Summary 1 $\varepsilon_{f1} = \varepsilon_f$ *and* $\varepsilon_{f2} > \varepsilon_f$

$\hat{\varepsilon}_{f1} < \varepsilon_{f1}$ *and* $\hat{\varepsilon}_{f2} < \varepsilon_{f2}$

$\varepsilon_{f2} > \varepsilon_{f1}$ *and* $\hat{\varepsilon}_{f2} > \hat{\varepsilon}_{f1}$

Marriage Transfers: At stage 7 of the sequence of events in the game, matched men and women bargain over the level of pre-marital transfers. It should be evident that all young women have the same outside option as they are indistinguishable from one another on the marriage market. Similarly, all older men have the same outside option and all older women have the same outside option.

Therefore, the level of premarital transfers agreed upon through a process of bargaining in any marriage involving a young woman (for whom a background check has revealed nothing) and an older man should be the same. We denote this level of transfers by τ_1.

Similarly, the level of premarital transfers agreed upon through a process of bargaining in any marriage involving an older woman (for whom a background check has revealed nothing) and an older man should be the same. We denote this level of transfers by τ_{22}.

Outside Options: Let us denote by v_{f1} and v_{f2} respectively the outside options of young women and older women on the marriage market. An older woman who does not marry in the current period will remain single hereafter. Therefore, her outside option is given by

$$v_{f2} = \zeta \underline{u}_f$$

where $\zeta = \frac{1}{1-\beta}$. A young woman who does not marry in the current period will re-enter the marriage market as an older woman. She would need to consider not only whether she will find a partner when she is older, but also whether a second background check would reveal bad moral character. Therefore, her probability of marrying as an older bride is given by $\lambda_2' = \lambda_2 (1 - \pi\varepsilon_{f2})$. Therefore, her outside option satisfies the following equation:

$$\begin{aligned} v_{f1} &= \underline{u}_f + \beta\zeta \left\{\lambda_2' u_f (\tau_2, \hat{\varepsilon}_{f2}) + \left(1 - \lambda_2'\right) \underline{u}_f\right\} \\ &= \left\{1 + \beta\zeta \left(1 - \lambda_2'\right)\right\} \underline{u}_f + \beta\zeta\lambda_2' u_f (\tau_2, \hat{\varepsilon}_{f2}) \end{aligned} \tag{6}$$

Let us denote by v_m the outside option of older men on the marriage market (Since young men do not marry by assumption, we need not consider their outside options for the analysis). An older man who does not marry in the current period will remain single hereafter. Therefore, his outside option is given by

$$v_m = \zeta \underline{u}_m$$

If an older man states a preference for a young bride, then a marriage with a young bride takes place with probability $\mu\left(\frac{n_{f1}}{\theta n_m}\right)(1 - \varepsilon_{f1})$. From this outcome, he receives a continuation utility of $\zeta u_m (\tau_1, \hat{\varepsilon}_{f1})$. Therefore, the expected utility to an older man from stating a preference for a young bride is given by

$$U_1 = \mu\left(\frac{n_{f1}}{\theta n_m}\right)(1 - \varepsilon_{f1}) \zeta u_m (\tau_1, \hat{\varepsilon}_{f1}) + \left[1 - \mu\left(\frac{n_{f1}}{\theta n_m}\right)(1 - \varepsilon_{f1})\right] v_m \tag{7}$$

If he states a preference for an older bride, then a marriage with an older bride takes place with probability $\mu\left(\frac{n_{f2}}{\theta n_m}\right)(1 - \varepsilon_{f2})$. From this outcome, he receives a continuation utility of $\zeta u_m (\tau_2, \hat{\varepsilon}_{f2})$. Therefore, the expected utility to an older man from stating a preference for an older bride is given by

$$U_2 = \mu\left(\frac{n_{f2}}{\theta n_m}\right)(1 - \varepsilon_{f2}) \zeta u_m (\tau_2, \hat{\varepsilon}_{f2}) + \left[1 - \mu\left(\frac{n_{f2}}{\theta n_m}\right)(1 - \varepsilon_{f2})\right] v_m \tag{8}$$

Bargaining: Given the outside options of older men, young women and older women on the marriage market, we can write the marital transfers that would occur in the different types of marriages as follows:

$$\tau_1 = \xi (v_m, v_{f1}, \hat{\varepsilon}_{f1}) \tag{9}$$

$$\tau_2 = \xi (v_m, v_{f2}, \hat{\varepsilon}_{f2}) \tag{10}$$

2.3 Equilibrium in the Marriage Market

In any period, the state of the marriage market can be fully described by the number of individuals in each age-gender group. By assumption, there are y young men and y young women in the marriage market in each period. As we have assumed that young men do not marry, there are also y older men in the marriage market each period. Therefore, the only quantity which can potentially vary over time is the number of older women in the marriage market.

If a fraction λ_1 of young women are matched with men in some period, then the number of older women in the marriage market in the *next* period is given by

$$n_{f2} = [1 - \lambda_1 + \lambda_1 \varepsilon\pi]\, y \tag{11}$$

The logic behind (11) is as follows: if a fraction λ_1 of young women are matched with men, then a fraction $\lambda_1 \varepsilon \pi$ will be discovered to have 'bad moral character'. Therefore, those who remain on the marriage market in the next period would include those who were not matched, numbering $(1-\lambda_1) y_1$ and those who were found to have 'bad moral character', numbering $\lambda_1 \varepsilon \pi y$. By construction, $\varepsilon \pi < 1$. Therefore, it follows from (11) that n_{f2} is decreasing in λ_1.

Letting $n_{f1} = n_{m2} = y$ in (1), we obtain

$$\lambda_1 y = \mu \left(\frac{y}{\theta y} \right) \theta y$$

Then, by Assumption 4, λ_1 is increasing in θ. It follows that n_{f2} is decreasing in θ. Therefore, the number of older women in the marriage market is declining in the fraction of men who (in the preceding period) state a preference for young brides.

Thus, we can represent the state of the marriage market with a single variable, λ_1 – the probability that a young woman will be matched with a potential groom –. which, in turn, is determined by θ, the proportion of men who state a preference for young brides.

We are now in a position to characterise equilibria in the marriage market. Let us denote by θ_t the value of θ in period t. From equation (7), we can see that the expected utility to older men in some period t, from stating a preference for young brides, U_1, depends on θ_t. The outside option of young brides, and therefore the equilibrium marriage payments depend on the marriage prospects of older women in the *next* period. Thus, the value of U_1 in period t also depends on θ_{t+1}. All other terms on the right-hand side of (7) are exogenously determined. Therefore, we can write the expected utility from stating a preference for a young bride as a function $U_1(\theta_t, \theta_{t+1})$.

From equation (8), we can see that the expected utility to older men in period t from stating a preference for older brides, U_2, also depends on θ_t. The reputation of older brides, and therefore the utility from marrying older brides depends on the proportion of young women who were married in the previous period. Thus, the value of U_2 in period t also depends on θ_{t-1}. All other terms on the right-hand side of (8) are exogenously determined. Therefore, we can write the expected utility from stating a preference for an older bride as a function $U_2(\theta_t, \theta_{t-1})$. It is straightforward to establish the following results.

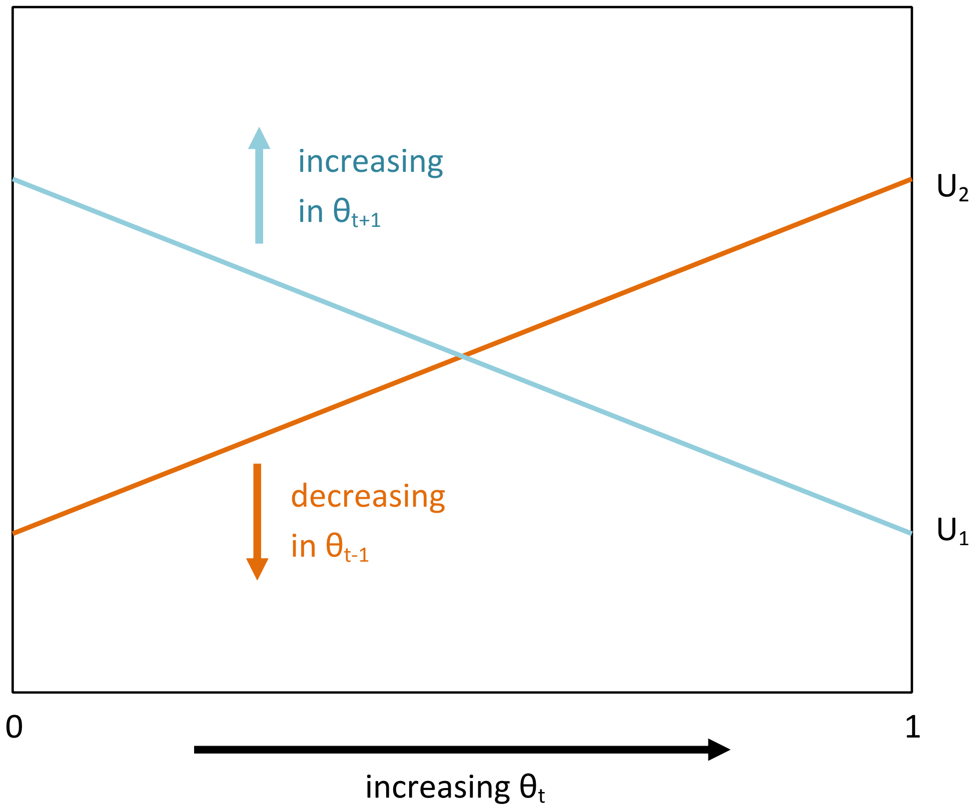
Lemma 1 *(i) Under Assumption 3,* $U_1(\theta_t, \theta_{t+1})$ *is strictly decreasing in* θ_t *and* $U_2(\theta_t, \theta_{t-1})$ *is strictly increasing in* θ_t*.*

(ii) Under Assumptions 1 and 5, $U_1(\theta_t, \theta_{t+1})$ *is strictly increasing in* θ_{t+1}

(iii) Under Assumption 8, $U_2(\theta_t, \theta_{t-1})$ *is strictly decreasing in* θ_{t-1}

Proof. *See the Appendix.* ∎

The first part of Lemma 1 follows directly from the properties of the functions $u_m(.,.)$ and $\mu(.)$. The second part of Lemma 1 has the following intuition: as the future marriage prospects of young women improve, they will require higher net marriage payments for marrying as young brides. Therefore, the expected utility to men from seeking young brides will decline. The third part of Lemma 1 has the following intuition: if a large fraction of men sought young brides in the preceding period, then the reputation of older women, and therefore the expected utility from seeking an older bride, is low in the current period.



If, in equilibrium, $\theta_t \in (0,1)$, then we must have $U_1(\theta_t, \theta_{t+1}) = U_2(\theta_t, \theta_{t-1})$. If not, some men would be able to improve their expected utility by changing their age preference for prospective bride. From Lemma 1(i), we see that $U_1(.)$ is monotonically decreasing, and $U_2(.)$ is monotonically increasing, in θ_t. Therefore there is, at most, one value of $\theta \in [0,1]$ which satisfies the preceding equation, as in Figure 1.

Similarly, we can reason that if $\theta_t = 0$, we must have $U_1(0, \theta_{t+1}) \leq U_2(0, \theta_{t-1})$ and if $\theta_t = 1$, then $U_1(1, \theta_{t+1}) \geq U_2(1, \theta_{t-1})$. These arguments enable us to compute the equilibrium value of θ_t whenever θ_{t-1} and θ_{t+1} are known. For this purpose, let us define function $I : [0,1] \times [0,1] \longrightarrow [0,1]$ as follows:

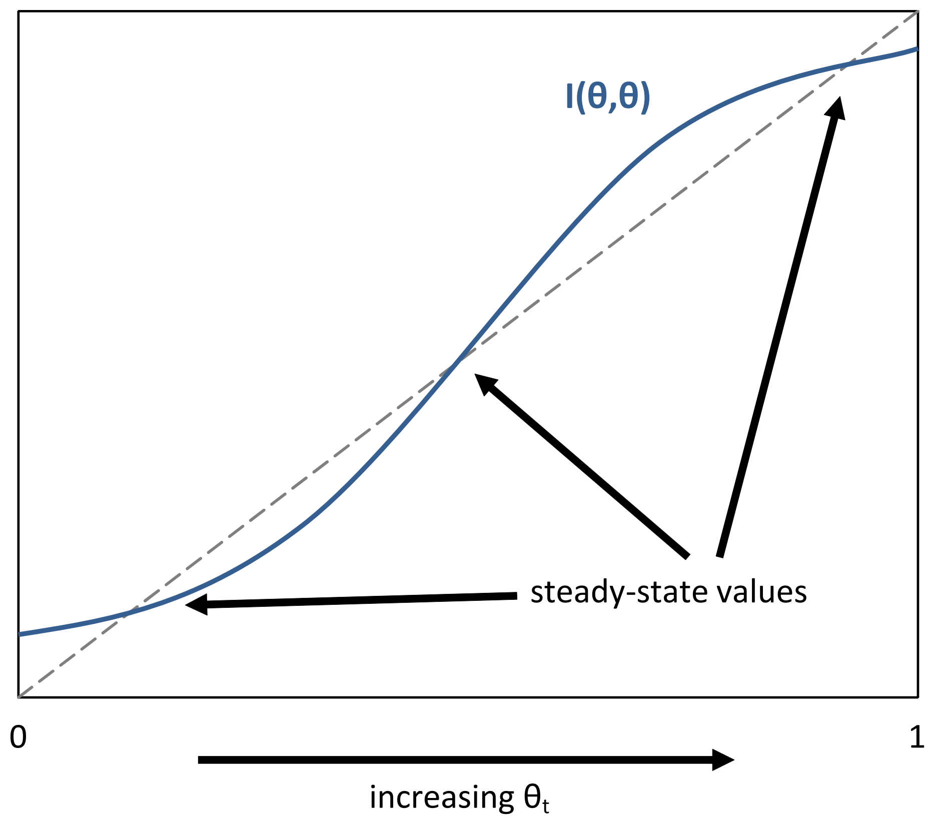
Definition 2

$$I(\theta_{t-1}, \theta_{t+1}) = \begin{array}{l} \theta \textit{ if } U_1(\theta, \theta_{t+1}) = U_2(\theta, \theta_{t-1}) \textit{ for some } \theta \in [0,1] \\ 0 \textit{ if } U_1(\theta, \theta_{t+1}) < U_2(\theta, \theta_{t-1}) \textit{ for each } \theta \in [0,1] \\ 1 \textit{ if } U_1(\theta, \theta_{t+1}) > U_2(\theta, \theta_{t-1}) \textit{ for each } \theta \in [0,1] \end{array}$$

Using this definition, we can establish the following result.

Proposition 1 *Given an initial value θ_0, the sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$ constitutes a Perfect Baysian Equilibriun if and only if $\theta_t = I(\theta_{t-1}, \theta_{t+1})$ for $t = 1, 2, ...$*

Proposition 1 provides us a convenient characterisation of all possible equilibria in the marriage market and the different ways in which the marriage age for women may evolve over time when all individuals in the marriage market are choosing their best response.



3 Steady-State Equilibria

Suppose there is some $\theta \in [0,1]$ which satisfies the following equation:

$$I(\theta, \theta) = \theta$$

In this case, the strategy profile where a fraction θ of men seek young brides in every period constitutes an equilibrium (when the initial value is also θ).

Lemma 2 *There exists at least one steady-state value $\theta \in [0,1]$; i.e. $I(\theta, \theta) = \theta$.*
Proof. *See the Appendix.* ■

Figure 2 shows a plot of $I(\theta, \theta)$ against θ. It follows from Lemma 1(i) that the curve is upward-sloping. At $\theta = 0$, it must lie on or above the 45-degree line and at $\theta = 1$, it must lie on or below the 45-degree line. From Lemma 2, we know that it must cross the 45-degree line at least once. Each value of θ where the curve crosses the 45-degree line constitutes a steady-state equilibrium. Below we provide two examples of potential steady-state equilibria.

1. Suppose $I(1,1) = 1$. Then, there exists a steady-state equilibrium in which, in each period, all men seek young brides.

   The probability that a young woman will find a match is given by $\lambda_1 = \mu\left(\frac{y}{y}\right)\frac{y}{y}$.

Older women do not receive any offers of marriage, and $\lambda_2 = 0$.

Therefore, $v_{f1} = v_{f2} = \zeta \underline{u}_f$; i.e. both young and older women have the same outside option.

Older women have worse 'reputation' than young women: $\varepsilon_{f2} > \varepsilon_{f1}$.

Furthermore, we have

$U_1 = \mu\left(\frac{y}{y}\right)(1 - \varepsilon_{f1})\,\zeta u_m(\tau_1, \hat{\varepsilon}_{f1}) + \left[1 - \mu\left(\frac{y}{y}\right)(1 - \varepsilon_{f1})\right] v_m$

$U_2 = \mu\left(\frac{\lambda_1 y}{1}\right)(1 - \varepsilon_{f2})\,\zeta u_m(\tau_2, \hat{\varepsilon}_{f2}) + \left[1 - \mu\left(\frac{\lambda_1 y}{1}\right)(1 - \varepsilon_{f2})\right] v_m$

$\tau_1 = \xi(v_m, v_{f1}, \hat{\varepsilon}_{f1})$

$\tau_2 = \xi(v_m, v_{f2}, \hat{\varepsilon}_{f2})$ (with $\hat{\varepsilon}_{f2}$ being derived from λ_1)

Since $\hat{\varepsilon}_{f2} > \hat{\varepsilon}_{f1}$, we have $\tau_1 < \tau_2$

Since $I(1,1) = 1$, we have $U_1(1,1) \geq U_2(1,1)$; i.e. the men obtain a higher expected utility from seeking a young bride as opposed to an older bride.

From the point of view of potential grooms, young brides are harder to find and they are more 'expensive'. But if the reputational effect offsets these disadvantages, we have a 'child marriage' equilibrium as described above. Alternatively, we could have the following situation.

2. Suppose $I(0,0) = 0$. Then, there exists a steady-state equilibrium in which, in each period, all men seek older brides.

Young women do not receive any offers of marriage and $\lambda_1 = 0$. Therefore, $n_{f2} = y$.

Older women receive offers of marriage with probability $\lambda_2 = \mu\left(\frac{y}{y}\right)\frac{y}{y}$.

Therefore, $v_{f1} = \{1 + \beta\zeta(1 - \lambda_2)\}\underline{u}_f + \beta\zeta\lambda_2 u_f(\tau_2, \hat{\varepsilon}_2)$ and $v_{f2} = \zeta\underline{u}_f$.

Since $\lambda_2 > 0$, we have, $v_{f1} > v_{f2}$; i.e. younger women have a better outside option than older women.

Older women have the same reputation as young women: $\varepsilon_{f2} = \varepsilon_{f1}$

Furthermore, we have

$U_1 = \mu\left(\frac{y}{1}\right)(1 - \hat{\varepsilon}_{f1})\,\zeta u_m(\tau_1, \hat{\varepsilon}_{f1}) + \left[1 - \mu\left(\frac{y}{1}\right)(1 - \hat{\varepsilon}_{f1})\right] v_m$

$U_2 = \mu\left(\frac{y}{y}\right)(1 - \hat{\varepsilon}_{f2})\,\zeta u_m(\tau_2, \hat{\varepsilon}_{f2}) + \left[1 - \mu\left(\frac{y}{y}\right)(1 - \hat{\varepsilon}_{f2})\right] v_m$

$\tau_1 = \xi(v_m, v_{f1}, \hat{\varepsilon}_{f1})$

$\tau_2 = \xi(v_m, v_{f2}, \hat{\varepsilon}_{f2})$

Since $v_{f1} > v_{f2}$, we obtain $\tau_1 < \tau_2$

Since $I(0,0) = 0$, we have $U_2(0,0) \geq U_1(0,0)$; i.e. the men obtain a higher expected utility from seeking an older bride as opposed to a young bride.

From the point of view of potential grooms, older brides are harder to find. But if the lower expense of older brides (they require a lower net marital transfer) offsets this disadvantage, we have a delayed marriage equilibrium.

For both examples, we obtain the result that young brides make a smaller net marital transfer than older brides. Note that $U_2(0,0) = U_1(1,1)$. In other words, the men receive the same expected utility in the two potential steady-state equilibria. This is because, if $\theta_{t-1} = 0$, the reputation of older women in period t is the same as that of young women; and, if $\theta_{t+1} = 1$, the outside option of young women in period t is the same as that of older women. Therefore, from the point of view of potential grooms, older women in the $\theta = 0$ steady-state are 'identical' – i.e. they have the same reputation and require the same net marital transfers – as younger women in the $\theta = 1$ steady-state.

There are, potentially, other steay-state equilibria where θ takes some fixed value between 0 and 1 in each period. This would mean that a fixed proportion of men seek young brides and others seek older brides, and the expected utility from the two choices are the same: $U_2(\theta,\theta) = U_1(\theta,\theta)$. In all of these equilibria, young women have a better outside-option and a better reputation than older women. Therefore, young brides make a smaller net marital transfer than older brides.

4 Equilibria with Varying θ

In the preceding section, we considered equilibria where a fixed proportion of men sought young brides in every period. Next, we consider a distinct class of equilibria; namely, those equilibria where this proportion changes over time. Note that although θ would change period by period, the marriage market would be in equilibrium in each period in the sense that all agents are choosing their best response, given the current state of the market and their expectation about the future. Furthermore, it is noteworthy that the marriage market can have such dynamics even though we have not, so far, introduced any external shocks or interventions.

The difficulty of analysing this class of equilibria is that they are driven by expectations about future values of θ. A marriage market where there is an expectation of wide prevalence of early marriage in the future would have a different trajectory from another marriage market where there is an expectation of a wide prevalence of late marriage. In other words, we can have multiple equilibria for the same initial value of θ.

Fortunately, there is one simple refinement that dramatically reduces the number of potential equilibria. The refinement is described in the following definition.

Definition 3 *Given an initial value θ_0, the sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$ constitutes a monotonic increasing equilibrium if $\theta_t = I(\theta_{t-1},\theta_{t+1})$ and $\theta_t \geq \theta_{t-1}$ for $t = 1,2,\ldots$. Given an initial value θ_0, the sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$ constitutes a monotonic decreasing equilibrium if $\theta_t = I(\theta_{t-1},\theta_{t+1})$ and $\theta_t \leq \theta_{t-1}$ for $t = 1,2,\ldots$.*

This refinement provides us considerable predictive power about how the age of marriage will evolve over time, using just the initial value of θ_0 and the fundamental parameters of the marriage market, as described in the following proposition.

Proposition 2 *(i) Given an initial value θ_0, there exists a monotonic increasing equilibrium if and only if there is a steady-state $\theta \in (\theta_0, 1]$. The equilibrium sequence $\{\theta_t\}_{t=1}^{\infty}$ converges to a steady-state $\theta \in (\theta_0, 1]$.*

(ii) Given an initial value θ_0, there exists a monotonic decreasing equilibrium if and only if there is a steady-state $\theta \in [0, \theta_0)$. The equilibrium sequence $\{\theta_t\}_{t=1}^{\infty}$ converges to a steady-state $\theta \in [0, \theta_0)$.

Proof. *See the Appendix.* ■

We can take an alternative approach based on the assumption that individuals are naive about their beliefs regarding the future marriage market; specifically, that their decisions in period t rely on the assumption that $\theta_{t+1} = \theta_{t-1}$. This assumption is unsatisfying in the sense that people are repeatedly wrong about their future beliefs in the marriage market. However, as we shall show, their beliefs grow more and more accurate over time as θ approaches a steady-state value; moreover, it generates a unique and easily computable equilibrium path in the marriage market.

Definition 4 *Given an initial value θ_0, the sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$ constitutes a Naive Expectations Equilibrium if, $\theta_t = I(\theta_{t-1}, \theta_{t-1})$ for $t = 1, 2, ...$*

Note that a 'Naive Expectations' equilibrium does not satisfy the criteria for a Perfect Bayesian equilibrium. A steady-state value of θ satisfies the conditions for both the Perfect Bayesian equilibrium and the 'Naive Expectations' equilibrium. The advantage of a 'Naive Expectations' equilibrium is that the initial value θ_0 uniquely determines the equilibrium path, as described in the following proposition.

Proposition 3 *Given an initial value θ_0, there is a unique sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$ that satisfies the criteria of a 'Naive Expectations' equilibrium. Furthermore,*

(i) if $I(\theta_0, \theta_0) > \theta_0$, then $\{\theta_\tau\}_{\tau=1}^{\infty}$ is an increasing sequence which converges to the smallest steady-state in the interval $(\theta_0, 1]$;

(ii) if $I(\theta_0, \theta_0) < \theta_0$, then $\{\theta_\tau\}_{\tau=1}^{\infty}$ is a decreasing sequence which converges to the largest steady-state in the interval $[0, \theta_0)$;

(iii) if $\theta_0 = I(\theta_0, \theta_0)$, then $\theta_\tau = \theta_s$ for $\tau = 1, 2, ...$

Proof. *See the Appendix.* ■

5 Changing the Opportunity Cost of Early Marriage

Interventions that improve access to secondary schooling or provide other training opportunities for girls can, potentially, raise their utility from singlehood. There are two channels through which it may do so. If attending school and participating in adolescent development programmes are enjoyable activities then such interventions would, in expectation, improve the quality of life for an adolescent. Attending school can, potentially, also improve one's ability to generate an income in later life, and consequently increase the expected utility from adulthood.

Marriage can make it considerably more difficult to access these opportunities. Field and Ambrus (2008) show that, in rural Bangladesh, age of marriage is a strong predictor for age of leaving school. Maertens (2012) finds, for villages in rural India, that parents' perception of what is an acceptable age of marriage is a significant predictior of their educational aspirations for their daughters, indicating that marriage and further education are regarded as mutually exclusive choices. Stipend programmes, such as the Female Secondary School Assistance Program (FSSAP) in Bangladesh, are often conditional on the pupil remaining single (Asadullah and Chaudhury 2009). Therefore, it is reasonable to assume that women who opt to marry while they are 'young' forgo further educational opportunities. If so, improved access to secondary schooling and adolescent development programmes would make singlehood more attractive, relative to marriage, for young women.

If so, then some women may find it in their interest to 'turn down offers of marriage' even if they are matched with a potential groom when they are young; in other words, Assumption 7 – according to which there is always some level of transfer between a potential bride and a potential groom such that both would prefer marriage to singlehood – may not hold true.

The effect of these opportunities on the marriage decision of older women is more ambiguous. Schooling can improve their outside options (e.g. access to the labour market, further education, or a different segment of the marriage market). But schooling can also improve the total marriage surplus over which the bride and the groom bargain. For the present analysis, we disregard this effect. This is equivalent to assuming that, for older women on the marriage market, improved access to schooling and adolescent development programmes do not affect the *relative* attractiveness of singlehood versus marriage.

In Section 5.2, we consider how improving opportunities of adolescent women – by improving access to schooling, or other opportunities for acquiring skills and knowledge – would impact upon the marriage marriage. We assume that women who do not marry young (whether because they were not matched with a potential groom, or were found to have 'bad moral character', or turned down an offer of marriage) choose to pursue schooling till they become 'older'. Therefore, all 'older' women on the marriage market would have attended school; and so their level of education do not provide any additional information about their 'moral character'.

To investigate the impact of programmes that improve the opportunities of adolescent women, we first need to analyse how the refusal of offers of marriage by some young women can affect the marriage market equilibrium. We do this in the next section.

5.1 Turning Down Offers of Marriage

Let us denote by $\underline{u}_{f1}$ the utility from singlehood when a woman is 'young' and, by $\underline{u}_{f2}$, the utility from singlehood when a woman is 'older'. To capture situations where some, but not all, young women may find it in their interest to turn down offers of marriage, we allow the utility from remaining single while young to vary across individuals. This may be due to differentiated access to secondary schools or adolescent development programmes, and differences in preferences. Specifically, let $\underline{u}_{f1} = y + \psi$ where y is a constant common to all individuals and ψ is distributed across individuals according to the cummulative distribution function $F(.)$.

We can define x as the threshold value of the utility from singlehood at which a young woman is indifferent between accepting and refusing an offer of marriage. Then, x must satisfy the following equation:

$$(1 + \beta\zeta)\, u_f(\tau_1, \hat{\varepsilon}_{f1}) = x + \beta\zeta \left[(1 - \lambda_2)\, \underline{u}_{f2} + \lambda_2 u_f(\tau_2, \hat{\varepsilon}_{f2})\right] \tag{12}$$

where τ_1 solves $u_m(\tau_1, \hat{\varepsilon}_{f1}) = \underline{u}_m$. Therefore, for $\underline{u}_{f1} > x$, a woman would, in effect, choose to delay marriage. If $F(x - y) = 1$, then we obtain the situation described in Section 2.3. If $F(x - y) < 1$, some matches involving young women will not lead to marriage even when the background check has not signalled 'bad moral character'. This has two implications for the marriage of young women on the marriage market. First, a potential groom is less likely to be matched with a young bride with whom a marriage contract can be negotiated. The probability of marriage for men who state a preference for young brides will be given by

$$\mu\left(\frac{n_{f1}}{\theta n_m}\right)(1-\varepsilon_{f1})\,F(x-y)$$

where θ, as before, is the proportion of men who seek young brides.

Second, if some women are postponing marriage when they are young, it provides an alternative reason why older women may be single (other than the two reasons discussed above: not being matched with a potential groom and being found to have 'bad moral character'); and, consequently, the reputation of older women on the marriage market would improve. Specifically, it is given as follows:

$$\begin{aligned}\varepsilon_{f2} &= \Pr(\text{bad}|\text{older})\\ &= \frac{\Pr(\text{older}|\text{bad})\Pr(\text{bad})}{\Pr(\text{older})}\end{aligned}$$

$$\Longrightarrow \varepsilon_{f2} = \frac{\varepsilon_f\left[(1-\lambda_1)+\lambda_1\pi+\eta\lambda_1(1-\pi)\right]}{(1-\varepsilon_f)\left[(1-\lambda_1)+\eta\lambda_1\right]+\varepsilon_f\left[(1-\lambda_1)+\lambda_1\pi+\eta\lambda_1(1-\pi)\right]} \tag{13}$$

where $\eta = 1-F(x-y)$ denotes the proportion of young women who turned down offers of marriage in the preceding period. If $\eta = 0$, the expression in (13) is identical to that in (3). As η increases, ε_{f2} declines; i.e. there is a fall in the probability of 'bad moral character' among older women on the marriage market. In addition, the number of older women in the marriage market will go up with the proportion of young women who declined offers of marriage in the *preceding* period (represented by η' below):

$$n_{f2} = \left[1-\lambda_1+\eta'\lambda_1\varepsilon\pi\right]y \tag{14}$$

Equations (13) and (12) together yield, for a given value θ, the threshold value x above which young women turn down offers of marriage and η, the proportion of young women who do so.[1] Let us denote these values by the functions $x(\theta)$ and $\eta(y,\theta)$ respectively. (We suppress the parameter y in the function $\eta(.)$ hereafter in this section for ease of notation. The consequences of changing y are explored in the next section).

As per the reasoning above, the expected utility to potential grooms from a seeking young bride, in a given period t, will depend on η_t, the proportion of young women who decline offers of marriage in that period. On the other hand, the expected utility from seeking an older bride will depend on η_{t-1}, because the proportion of young women who declined offers of marriage in the preceding period determines, as per (13), the reputation of older women in the current period. We can therefore represent the expected utilities by $\hat{U}_1(\theta_t,\theta_{t+1},\eta_t)$ and $\hat{U}_2(\theta_t,\theta_{t-1},\eta_{t-1})$ respectively. Using these expected utility functions, we can define a function $\hat{I}(.)$ akin to the function $I(.)$ introduced in Section 2.3:

[1]Note that λ_1 and λ_2 can be determined from θ using equations (1), (2) and (14). The remaining variables in equation (12), τ_1, τ_2 and $\hat{\varepsilon}_{f1}$, are exogenously determined.

Definition 5

$$\hat{I}\left(\theta_{t-1},\eta_{t-1},\theta_{t+1}\right)=\begin{array}{l}\theta \textit{ if } \hat{U}_1\left(\theta,\theta_{t+1},\eta\left(\theta\right)\right)=\hat{U}_2\left(\theta,\theta_{t-1},\eta_{t-1}\right) \textit{ for some } \theta\in[0,1]\\ 0 \textit{ if } \hat{U}_1\left(\theta,\theta_{t+1},\eta\left(\theta\right)\right)<\hat{U}_2\left(\theta,\theta_{t-1},\eta_{t-1}\right) \textit{ for each } \theta\in[0,1]\\ 1 \textit{ if } \hat{U}_1\left(\theta,\theta_{t+1},\eta\left(\theta\right)\right)>\hat{U}_2\left(\theta,\theta_{t-1},\eta_{t-1}\right) \textit{ for each } \theta\in[0,1]\end{array}$$

Using the definition of $\hat{I}\left(\theta_{t-1},\eta_{t-1},\theta_{t+1}\right)$, we can provide a characterisation of equilibria as follows.

Proposition 4 *Given initial values θ_0 and η_0, a sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$ constitutes a Perfect Bayesian Equilibrium if and only if, we have $\theta_t=\hat{I}\left(\theta_{t-1},\eta_{t-1},\theta_{t+1}\right)$, where $\eta_t=\eta\left(\theta_{t-1}\right)$, for $t=1,2,....$*

There exists a steady-state equilibrium at $\theta\in[0,1]$ if and only if $\theta=\hat{I}\left(\theta,\eta\left(\theta\right),\theta\right)$. In other words, if the proportion of men seeking young brides, and the proportion of young women who decline offers of marriage, are equal to θ and $\eta\left(\theta\right)$ respectively in some period, and $\theta=\hat{I}\left(\theta,\eta\left(\theta\right),\theta\right)$, then there exists an equilibrium where these proportions remain the same in all future periods.

5.2 Formal Analysis

We are now in a position to investigate, formally, how improving access to schooling impacts upon the marriage market equilibrium. It is reasonable to represent improved access to schooling as an increase in the common component in the utility of singlehood from y to, say, y'. For ease of comparison, suppose that the marriage market is initially in a steady-state equilibrium; i.e. a fixed proportion of men, θ_s seek young brides in each period, where $\theta_s=\hat{I}\left(\theta_s,\eta\left(y,\theta_s\right),\theta_s\right)$. Let us denote by v the first period of the intervention.

Note that, in the first period following the intervention, the reputation of older women on the marriage market is unaffected by the intervention itself (assuming that the intervention was unanticipated); as their reputation is determined by the proportion of men seeking young brides, and the proportion of young women who turned down offers of marriage, in the *preceding* period. Therefore, for any value of θ_v, the expected utility to men from seeking older brides is the same as it would have been in the absence of the intervention: $\hat{U}_2\left(\theta_v,\theta_s,\eta\left(y,\theta_s\right)\right)$.

On the other hand, the expected utility from seeking a young bride depends on the proportion of young women who turn down offers of marriage in the current period. As a result of improved access to secondary schooling, a higher proportion of women will turn down offers of marriage in period v for any expectation of θ_{v+1}: $\eta\left(y',\theta_{v+1}\right)>\eta\left(y,\theta_{v+1}\right)$. This would make it less attractive, given any pair θ_v,θ_{v+1}, for men to seek young brides (as doing so will be less likely to lead to a marriage): $\hat{U}_1\left(\theta_v,\theta_{v+1},\eta\left(y',\theta_{v+1}\right)\right)<\hat{U}_1\left(\theta_v,\theta_{v+1},\eta\left(y,\theta_{v+1}\right)\right)$.

There are, potentially, multiple Perfect Bayesian equilibria following the intervention, each corresponding to a different value for θ_{v+1}. The intervention itself provides no guidance about which of these Perfect Bayesian equilibria may be realised. Therefore, we focus instead on the 'Naive Expectations' equilibrium which, as per Propositon 3, is uniquely determined by θ_s. In this case, θ_v solves the equation

$$\hat{U}_1\left(\theta_v,\theta_s,\eta\left(y',\theta_s\right)\right)=\hat{U}_2\left(\theta_v,\theta_s,\eta\left(y,\theta_s\right)\right) \tag{15}$$

It follows that $\theta_v<\theta_s$.[2]

[2] To see this, note that

$$\hat{U}_1\left(\theta_s,\theta_s,\eta\left(y',\theta_s\right)\right)<\hat{U}_1\left(\theta_s,\theta_s,\eta\left(y,\theta_s\right)\right)$$

Then, in period $v+1$, the reputation of older women improve for two reasons: (i) a lower proportion of them received offers of marriage when young than the preceding cohort ($\theta_v < \theta_s$) and, (ii) compared to the preceding cohort, a larger proportion of those who received offers of marriage when young refused them ($\eta(y', \theta_s) > \eta(y, \theta_s)$). Therefore, in the second period of the intervention, the expected utility to men from seeking older brides will be higher, for any value of θ_{v+1}, than in period v:

$$\hat{U}_2(\theta_{v+1}, \theta_v, \eta(y', \theta_v)) > \hat{U}_2(\theta_{v+1}, \theta_s, \eta(y, \theta_s))$$

$$\Longrightarrow \hat{U}_2(\theta_v, \theta_v, \eta(y', \theta_v)) > \hat{U}_1(\theta_v, \theta_s, \eta(y', \theta_s)) \text{ using (15)}$$

$$\Longrightarrow \hat{U}_2(\theta_v, \theta_v, \eta(y', \theta_v)) > \hat{U}_1(\theta_v, \theta_v, \eta(y', \theta_v)) \text{ using Lemma 1(ii)}$$

Therefore, $\theta_{v+1} < \theta_v$.

Then, in period $v+2$, the reputation of older women improves once again as (i) a lower proportion of them received offers of marriage when young than the preceding cohort ($\theta_{v+1} < \theta_v$) and, (ii) compared to the preceding cohort, a larger proportion of those who received offers of marriage when young refused them ($\eta(y', \theta_v) > \eta(y', \theta_s)$). Thus, the cycle continues.

Therefore, even if an intervention initially affects the outside options of only a subset of young women, it can initiate a virtuous cycle in the marriage market such that more and more women opt not to marry when they are young. The marriage market will reach a new steady state at θ'_s, which satisfies the equation

$$\theta'_s = \hat{I}\left(\theta'_s, \eta\left(y', \theta'_s\right), \theta'_s\right)$$

It is straightforward to show that $\theta'_s < \theta_s$.

6 Discussion

In recent years, international donors and development agencies have designed and implemented a range of interventions aimed at expanding the economic and educational opportunities of adolescents, particularly girls, in developing countries; with the reduction of the incidence of child marriage and postponement of childbirth among their intended goals.

In this context, it is important to realise that decisions regarding the timing of marriage of a son or daughter, although they are made within a single household, may be influenced by the choices made by other households in the community or region. In this paper, we investigated a particular mechanism through which these individual choices can influence the costs and benefits of early marriage versus late marriage for everyone in a marriage market: if some qualities of prospective brides are not fully observable at the time of marriage, then the incidence of child marriage will influence the perceived quality of older women on the marriage market.

In this situation, expanding opportunities for some adolescent girls – to the extent that they or their parents choose to postpone their marriage – can trigger a virtuous cycle whereby the perceived quality of

Since $\hat{U}_1(.)$ is decreasing in its first argument and $\hat{U}_2(.)$ is increasing in its first argument, it follows that $\theta_v < \theta_s$.

older brides improve, which in turn makes it more attractive for other girls to postpone marriage, and so on. In a study of the timing of marriage and childbearing in rural Bangladesh (Schuler et al., 2006), this idea is succinctly captured in a reported interview with an 18-year-old girl:

> '... when asked why her parents had delayed her marriage while her younger sisters had married at ages 12-15 ... [she replied] "My father thought it was unnecessary for girls to read and write but in my case he did not object ... None of my peers were sitting idle at home so I also went to school. Now it is better for girls. They don't have to pay school fees – the government finances it ... Everyone has had some schooling, at least up to the eighth or ninth grade. No one would want to marry an illiterate girl so they are sent to school." p. 2831

The fact that an intervention targeted at adolescent girls can make it more and more attractive for future cohorts to postpone marriage means that the long-term impact of such interventions on marriage and subsequent life choices may well exceed the immediate impact.

7 Appendix

Proof. of Lemma 1: (i) By Assumption 3, $\mu\left(\frac{n_{f1}}{\theta_t n_m}\right)$ is strictly decreasing in θ_t. Therefore, using the definitions of $U_1(\theta_t, \theta_{t+1})$ and $U_2(\theta_t, \theta_{t-1})$ in (7) and (8), we have $U_1(\theta_t, \theta_{t+1})$ strictly decreasing in θ_t and $U_2(\theta_t, \theta_{t-1})$ is strictly increasing in θ_t.

(ii) Using (6), we see that the outside option of young women in period t, v_{f1}, is increasing in the value of λ_2 in period $t+1$. Using (2), λ_2 is decreasing in θ_{t+1}. Therefore, v_{f1} is decreasing in θ_{t+1}.Then, using (9) and Assumption 5, τ_1 is increasing in v_{f1}. It follows from (7) and Assumption 1 that U_1 is increasing in θ_{t+1}.

(iii) Using (3), ε_{f2} in period t is increasing in λ_1 in period $t-1$. Using (1), λ_1 is increasing in θ_{t-1}. Therefore, ε_{f2} is increasing in θ_{t-1}. Then, using (8) and (10) and Assumption 8, U_2 is decreasing in θ_{t-1}. ■

Proof. of Lemma 2: Define $J(\theta) = I(\theta, \theta) - \theta$. Given that $u_m(.)$, $\mu(.)$ and $\xi(.)$ are continuous functions, so is $J(.)$. By construction, $J(\theta) \geq 0$ at $\theta = 0$ and $J(\theta) \leq 0$ at $\theta = 1$. If $J(0) = 0$ or $J(1) = 0$, then the corresponding θ value would constitute a steady-state. If $J(0) > 0$ and $J(1) < 0$, then it follows from the Intermediate Value Theorem that there exists some $\theta \in [0,1]$ such that $J(\theta) = 0$. Therefore, $I(\theta, \theta) = \theta$. ■

Proof. of Proposition 2: (i) Consider a monotonic increasing sequence $\{\theta_t\}_{t=0}^{\infty}$ where $\theta_t \in [0,1]$ for all t. First, we show that this sequence has a point of convergence in the interval $(\theta_0, 1]$. Let $x = \sup\{\theta_t\}$. By definition, for each $\varepsilon > 0$, $\exists T \in \mathbb{N}$ such that $|\theta_T - x| < \varepsilon$ (if not, x would not be the supremum of the sequence). Given that $\{\theta_t\}_{t=0}^{\infty}$ is a monotonic sequence, it follows that $|x - \theta_t| < \varepsilon$ for $t \geq T$.

Therefore, for $r, s \geq T$, we obtain

$$\begin{aligned} |\theta_r - \theta_s| &\leq |x - \theta_r| + |x - \theta_s| \\ &\leq 2\varepsilon \end{aligned}$$

Therefore, $\{\theta_t\}_{t=0}^{\infty}$ constitutes a Cauchy sequence. Every Cauchy sequence of real numbers has a limit (see, for example, Lang, p.143). Therefore, $\{\theta_t\}_{t=0}^{\infty}$ has a limit. Let $y = \lim_{t\to\infty}\{\theta_t\}$. It follows that $y = \sup(\theta_t) = x$.

Next, we show that y corresponds to a steady-state equilibrium, i.e. $I(y,y) = y$. We prove this by contradiction. Suppose $I(y,y) > y$. Then, as $I(.)$ is continuous in both arguments, we can find ε sufficiently small such that

$$I(y-\varepsilon, y-\varepsilon) > y$$

Given the convergence property of $\{\theta_t\}_{t=0}^{\infty}$, there exists T sufficiently large such that for $t \geq T$, we have $\theta_t > y - \varepsilon$. Therefore,

$$I(\theta_T, \theta_{T+2}) > y$$

$$\Longrightarrow \theta_{T+1} > y$$

This contradicts the earlier statement that y is the supremum of the sequence.

Now suppose that $I(y,y) < y$ and let $z = y - I(y,y) > 0$. Consider some $\delta > 0$. By Lemma 1 and continuity of $I(.)$, we have, for each $\theta_1, \theta_2 \in (y-\delta, y)$

$$I(\theta_1, \theta_2) \leq y - z$$

Given the convergence property of $\{\theta_t\}_{t=0}^{\infty}$, there exists T sufficiently large such that for $t \geq T$, we have $\theta_t \in (y-\delta, y)$. Therefore for each $r \geq T+1$, we have

$$\theta_r = I(\theta_{r-1}, \theta_{r+1}) \leq y - z$$

Therefore,

$$\sup\{\theta_t\}_{t=T+1}^{\infty} \leq y - z$$

Given that the sequence $\{\theta_t\}_{t=0}^{\infty}$ is monotonic, we have

$$\sup\{\theta_t\}_{t=0}^{\infty} \leq y - z < y$$

which contradicts the earlier statement that y is the supremum of the sequence. Therefore, it must be that y corresponds to a steady-state equilibrium.

(ii) The proof for a monotonic decreasing sequence proceeds in the same manner as above, such that we let $x = \inf\{\theta_t\}$ and show that the sequence converges to x. Using the reasoning by contradiction used above, we then show that x is a steady-state value, i.e. $I(x,x) = x$. ■

Proof. of Proposition 3: Given θ_0, we can construct a sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$ as follows. Let $\theta_{t+1} = I(\theta_t, \theta_t)$ for $t = 1, 2, ...$ By construction, the sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$, together with the initial value θ_0, satisfies the definition of a 'Naive Expectations' equilibrium in 4. Furthermore, as $I(.,.)$ is increasing in both arguments by Lemma 1,given θ_0, no other sequence $\{\theta'_\tau\}_{\tau=1}^{\infty}$ can satisfy the definition in 4. Therefore, given the initial value θ_0, there is a unique sequence that satisfies the criteria of the 'Naive Expectations' Equilibrium.

(i) Suppose $I(\theta_0, \theta_0) > \theta_0$. As $I(1,1) \leq 1$, and $I(.,.)$ is a continuous function, it follows that there exists at least one steady-state value in the interval $(\theta_0, 1]$. Let us denote the first (i.e. smallest) of these steady-state values as θ_s; i.e. $I(\theta_s, \theta_s) = \theta_s$. By continuity of $I(.,.)$, we have $\theta < I(\theta, \theta)$ for $\theta \in [\theta_0, \theta_s)$.

By construction, $\theta_1 = I(\theta_0, \theta_0)$. Since $\theta_0 < I(\theta_0, \theta_0)$, we have $\theta_1 > \theta_0$. We can show by contradiction that $\theta_1 < \theta_s$. Define $K(\theta) = I(\theta, \theta)$. By Lemma 1, $K(\theta)$ is increasing in θ. Therefore, $K^{-1}(.)$ is an increasing function. Therefore, if $\theta_1 > \theta_s$, then $K^{-1}(\theta_1) > K^{-1}(\theta_s)$. By construction, $K(\theta_0) = I(\theta_0, \theta_0) = \theta_1$. Therefore $K^{-1}(\theta_0) = \theta_1$. Therefore $\theta_0 > \theta_s$, which is a contradiction of our initial premise.

By the same reasoning, $\theta_2, \theta_3... < \theta_s$. Since $I(\theta, \theta) > \theta$ for $\theta < \theta_s$, it follows that $\{\theta_\tau\}_{\tau=1}^{\infty}$ is an increasing sequence. Following the proof of Proposition 2, we can show that the sequence converges to $y = \sup\{\theta_\tau\}$ and that y corresponds to a steady-state. As all elements of the sequence are smaller than θ_s, it follows that the steady-state must be θ_s.

(ii) Suppose $I(\theta_0, \theta_0) < \theta_0$, As $I(0, 0) \geq 1$ and $I(.,.)$ is a continuous function, it follows that there is at least one steady-state value in the interval $[0, \theta_0)$. Let us denote the largest of these steady-state values as θ_s'; i.e. $I(\theta_s', \theta_s') = \theta_s'$. Following the reasoning in part (i) above, we can show that sequence$\{\theta_\tau\}_{\tau=1}^{\infty}$ is a decreasing sequence that converges to θ_s'.

(iii) Suppose $I(\theta_0, \theta_0) = \theta_0$. Since $\theta_{t+1} = I(\theta_t, \theta_t)$ for $t = 1, 2, ..$, it follows that $\theta_1 = I(\theta_0, \theta_0) = \theta_0$, and $\theta_2 = I(\theta_1, \theta_1) = I(\theta_0, \theta_0) = \theta_0$, etc. Therefore, each element of the sequence $\{\theta_\tau\}_{\tau=1}^{\infty}$ is equal to θ_0. ∎

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