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MINIMUM AGE OF MARRIAGE, DOWRY AND INVESTMENT IN DAUGHTER'S HUMAN CAPITAL: A GAME-THEORETIC EXPLORATION

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Early marriage, especially of women, is a common phenomenon in developing countries like India. Given the well-established negative consequences that early marriage entails, several countries have enacted some form of minimum age of marriage law for women. However, such a legislation may entail a perverse consequence for the daughter in dowry-paying societies. This paper game-theoretically explores the impact of a rise in legal minimum age of marriage for women on the amount the parents spend on the daughter's human capital accumulation. It argues that such a legal mandate may force the household to earmark less on the daughter's human capital accumulation, because later marriages entail higher dowry expenditures. Hence poor parents are forced to save more for future dowry by spending less on their daughter's human capital. Hence higher future dowries are financed by cutting back on daughter's human capital investments.

Keywords: Minimum Age of Marriage, Dowry, Human Capital Investment
JEL Classification: J12, J16

1. INTRODUCTION

Savitri had lost her husband and her two children when a mysterious disease – possibly cerebral malaria - visited her village. A salishi sabha, village council, had sat in judgement and decided that Savitri had a hand in the plague. They declared her a witch and asked her to pay a hefty fine of two lakh rupees and arrange for a feast for the entire village. Her husband owned two acres of land that were now legally hers. ... Savitri had also committed another crime. When the census people came to her village, they had enlisted her as literate. So here was a woman who could read and write, who owned a plot of land, and who, according to the salishi sabha, had killed her husband and children. As a witch Savitri had three options: to pay up, be killed, or flee. She chose the third option.

(Page 117, Dumurdi Vidyashram, Ayodhya Hill)

From Field Notes from a Waterborne Land, Bengal beyond the Bhadralok, by Parimal Bhattacharya

Often there is a yawning gap between an expected or intended outcome and an actual outcome, when a policy is put in place1. This paper examines such a situation pertaining to minimum marriage age legislations. How does a rise in mandatory minimum age of marriage affect spending on daughter's human capital? Does it unambiguously lead to positive outcomes for her? This is the question we explore here.

Early marriage among girls is a common phenomenon in the developing world. To summarize a substantial literature, women who marry early are subject to lower education and lower labour force participation, less autonomy, little bargaining power and decision making power in the household, higher threat of domestic violence, poorer health and health related risk due to early childbearing (see Jensen and Thornton, 2003; Field and Ambrus, 2008; McGavock, 2021; Chari et al., 2017; Parsons et al., 2015 for overall discussions on ill-consequences of early marriage).

On the other hand, a rise in the age of marriage of women can reduce maternal mortality and can improve maternal and child health by delaying first childbirth. It can also potentially increase women's educational and therefore labour market outcomes (see, for example, Chari et al., 2017; Field and Ambrus, 2008 for positive consequences of a delay in marriage). Hence governments of several countries have considered some form of minimum age of marriage law for women[2]. This paper shows, that in a dowry-paying society, such a law can also have the perverse effect of reducing what parents' earmark for their daughter's human capital.

We hypothesize, that this seemingly counter-intuitive result of increasing minimum marriage age leading to lower human capital investment comes through the channel of dowry. Dowry is a payment made by the bride's side to the groom's side at the time of marriage (see Anderson, 2007; Chiplunkar and Weaver, 2023, for example)[3]. As widely

[1] As the opening quote suggests, often policies that are universally assumed to have positive impacts, do not have so. For example, literacy and ownership of assets like land, should have empowered the widow. But in fact, it was just the opposite.

[2] See Arthur et al (2018) for a comprehensive discussion on age of marriage laws worldwide. They note, as of 2013, 168 out of 191 countries had 18 as the general minimum age of girls' marriage. However, various kinds of exceptions were granted in various countries. For example, 99 countries allowed girls to marry before 18 with parental consent. Recently, the Indian government has introduced the Prohibition of Child Marriage (Amendment) Bill to increase the minimum age of marriage for women from 18 to 21, keeping that for men unchanged at 21. For a discussion on the proposed bill, see: https://www.thehindu.com/news/national/increase-in-minimum-ageof-marriage-for-women-to-21-years-two-years-after-bill-is-notified-centre/article66622738.ece (Accessed on 25-09-2023), https://www.livemint.com/news/india/increasing-legal-age-of-marriage-to-21-is-it-a-boon-ora-bane-for-indian-women-international-women-s-day-11646540444993.html (Accessed on 25-09-2023).

[3] Transfer of wealth at the time of marriage is quite common in the developing world. In South Asia, it is mainly directed from the bride's side to the groom's side, which is termed as dowry. Dowry practice is almost universal in both India and Pakistan (Anderson, 2007). The amount is also quite sizeable, in India, dowry amount usually exceeding annual income of a household (Chiplunkar and Weaver, 2023).

shown in the literature, a higher age of marriage of the bride leads to a higher dowry payment at the time of marriage (see, for example, Calvi and Keskar, 2021; Field and Ambrus, 2008). Again, an increase in daughter's marriage age due to a rise in legal minimum age of marriage can also increase her education level (Field and Ambrus, 2008).

So, following a rise in minimum age of marriage for women, there might be two effects: first, women can now be more educated at the time of marriage, second, their age at the time of marriage is now higher. However, research shows that son's families prefer younger brides and women's education is rarely valued in the marriage market (Calvi and Keskar, 2021; Field and Ambrus, 2008; Buchman et al., 2023). Given that, a rise in legal minimum age of marriage makes a woman less attractive to the groom's family and thus the latter derives a lower utility from marriage. To compensate for that, they ask for a higher dowry. Anticipating that beforehand, daughters' parents save more for paying the higher dowry[4], and to finance that, poor families are forced to spend less on their daughters' human capital[5].

Related Literature. This paper is a theoretical exploration on how a minimum marriage age legislation, through the channel of dowry, impacts parental human capital investment decision on a daughter. It contributes to two different strands in the literature. The first one is the theoretical literature on dowry where our paper adds to the literature on application of sequential game of incomplete information in dowry-related modelling.

Most of the theoretical literature on marital payments start from the seminal work by Becker (1973) (see Anderson, 2007 for a discussion). If the rule of division of output within the marriage is inflexible, so that the share of income of each spouse is not the same as under the market solution, then an up-front compensatory transfer will be made between the spouses and efficiency will be restored. Thus, if the wife's share of family income is below her shadow price in the marriage market, then a bride price will be paid by the groom's family to the bride or her family, and in the other case, where wife's share is more than her shadow price, the transfer will go in the reverse direction from the bride's side to the groom's side, which is called a dowry. The division of marital surplus is likely to be inflexible when there are jointly consumed household goods like housing and children. Also legal restrictions, social norms, or an implicit imbalance of power within the household could restrict the efficient division of surplus. Therefore, it predicts that marriage payments should be common.

Botticini and Siow (2003), in a different theory of dowry, show that parents give dowry to their daughters as a pre-mortem bequest. Their model shows that in a virilocal society (where women leave their natal homes and move to their husbands' family upon

[4] Daughters' parents do form very good forecasts about future dowry payments that they have to make. See Maertens and Chari (2020), Anukriti et al(2022). They also note that prospect of higher dowry payments at the time of a daughter's marriage leads parents to save more in advance.

[5] As Anderson (2014) notes, dowry payments force parents to disinvest in female human capital.

marriage), altruistic parents will give dowry to daughters and bequest to sons in order to solve a potential free-riding problem between them. They also show that dowry will disappear with development of labour market.

Anderson (2003) shows that the rise in dowry with modernization in India can be explained by the existence of caste institution in India. It shows that, modernization, which comes with higher wealth dispersion within caste groups, will increase the dowry amount. It also predicts that when endogamy breaks down and caste no longer remains an important determinant of status, dowry should decline.

Munshi (2012) surveys the theoretical literature on dowry with a special focus on both groom's and bride's education. She observes that a higher level of dowry is often associated with a higher level of education of the groom. Munshi (2017) formalizes this observed direct relation between groom's education and dowry using a contract theoretic model under asymmetric information. The quality of the potential groom is unobservable to the potential bride, and groom's education acts as a signal of his quality. Here dowry is used as a screening instrument for the unobservable quality of the groom. Menu of education and dowry contracts is used to separate the types of grooms where high type grooms select the contract with higher education and higher dowry.

Anderson and Bidner (2015) explain the fall in bride's property rights over dowry with economic development. Among other findings, their model determines and analyzes direction of changes in dowry and shares of the spouses in dowry with return to female human capital, wife's bargaining power, and effectiveness of formal property rights of women.

Though there are a number of different theories on causes and consequences of the dowry practice, yet the theoretical literature does not particularly talk about the impact of a higher dowry on daughter's human capital investment, which is the focal point here. Anderson and Bidner (2015) explains a reduction in dowry with an increase in the level of female human capital, but it does not talk about the reverse direction, effect of a change in dowry on female human capital.

Secondly, as we discuss how a minimum age of marriage law might have an adverse effect on educational investment in the daughter, our paper falls in the literature on potential impacts of a minimum age of marriage law for women. Though the impact assessment literature about such a law is empirical (some of which we discuss below), daughter's age at marriage is a strategic decision for her family when there are payments involved in marriage6. In a society where dowry is practiced, daughter's marriage timing is a crucial decision for her family as it is also the time for a large expenditure7. To capture this strategic aspect of decision-making, we consider a game-theoretic

[6] For example, Corno et al (2020) show that households use daughter's age at marriage as a strategy to smooth consumption, bringing it forward in case of a brideprice and delaying it in the case of a dowry.

[7] In the sample used by Deolalikar and Rao (1998), average dowries are equal to 68 percent of total assets before marriage and can amount to six times the annual wealth of the bridal family. See Anderson (2003) for other survey results on the amount of dowry in the context of India.

modelling.

In the empirical literature, a number of papers have documented how an age of marriage law affects various women-specific outcomes other than education. McGavock (2021) finds that age of consent law in Ethiopia causes a reduction in probability of under 16 marriage of girls by 6.8 percentage points relative to the mean at baseline. It also shows that women's total lifetime fertility will be lower as a result of later marriage. Rokicki (2021) also finds a positive impact of such a law in the Ethiopian context. She shows, implementation of the law was associated with a 9-percentage- point reduction in risk of adolescent birth for exposed cohorts, an 8-percentage-point reduction in child marriage, and a 10-percentage point reduction in sexual initiation before age 18. Maswikwa et al. (2015) also reveals that minimum age laws were successful in reducing child marriage and early motherhood of teenagers in the context of 12 Sub- Saharan African countries. However, Batyra and Pesando (2021) do not find minimum age at marriage laws very effective.

Our focus here is two-fold: (i) how a rise in minimum legal age of marriage for women affects the dowry, and (ii) how family's decision on how much to expend on the daughter changes as dowry changes. In this regard, the two papers that are most closely related with our idea are Bharadwaj (2015), and Field and Ambrus (2008).

Bharadwaj (2015) empirically assesses the impact of Mississippi marriage law, which increased the minimum marriage age for women from 12 to 15 years and for men from 14 to 17 years, on human capital investment and finds an increase in school enrolment of girls. However, marriage market in Mississippi is not characterized by the practice of dowry.

Field and Ambrus (2008) study the impact of a delay in marriage on educational outcomes of girls. In the context of rural Bangladesh, the paper finds that such a delay has positive effects on girls' education. Specifically, they show that a delay in marriage by one year between ages 11 and 16 is associated with 0.22 additional year of schooling. They also find an increase in the use of preventive health measures. This paper discusses the prevalence of dowry in rural Bangladesh. In line with our model, it finds an increase in dowry payment with a rise in bride's age as a consequence of the minimum marriage age law, but it shows improved educational outcomes for girls.

However, unlike this paper, our focus is on expenditure made on the daughter's human capital rather than her human capital outcomes like educational attainment. Though these two variables might be positively linked, parents' investment in daughter's education and their educational outcomes may be different due to policies like education subsidy. For example, in the case of Bangladesh, the country under study in Field and Ambrus (2008), there was the Female Secondary School Stipend Program (FSSSP) (see Hahn et al. (2017) for details), which provided free secondary education for rural girls in Bangladesh. In such a case, a rise in girls' education level may not necessarily be a result of a rise in parental investment in their daughter's human capital.

Here we provide a simple game-theoretic set-up with dowry and spending on human capital where a rise in the minimum age of marriage can raise the dowry women have to pay, and thus forces poor parents to cut spending on daughter's human capital to pay for this increased dowry. The idea here is that, if daughter's existing age at marriage is very low, then with the rise in minimum age at marriage, her actual age at marriage will increase. This leads to an increase in the dowry groom's family demands from her family. Given that dowry has increased, daughter's parents with income constraint are forced to spend less on their daughter's education so that they can afford the dowry.

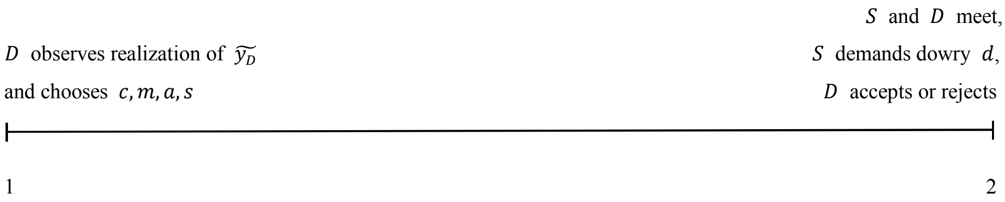

Figure 1. Timeline of the Game

The rest of the paper is organized as follows: Section 2 lays down the general model, Section 3 analyses the general model, Section 4 presents a parameterised example, and Section 5 concludes

2. THE MODEL

Rows of boxes marked with 'P' tapered off into dots and finally joined to become unbroken red lines.... "You could have met some of the girls missing in the classroom if you had come two weeks ago... They had taken shelter in my school. This year we shifted forty-two families. Most have returned home. Now they are busy - repairing the cottages, cleaning up homestead lands, preparing the plots for the robi crop. It's a lot of work. Some have lost their cattle, some have lost everything. Those who don't own land will find no work in the village for the next few months. They'll migrate to other states. These girls shall run the household. A few shall go to towns as housemaids. ... The money they earn will buy them a pair of goats, as investments, or a pair of gold earrings for their wedding. A few of them will never return." Every year, according to the National Crime Records Bureau, an average of four thousand girls go missing in West Bengal. Many of them are school going children. Sometimes, it all begins with dots in the school's attendance register, that soon join to form unbroken red lines.

(Page 33 - 40, A Water Sutra, Ganga Ichhamati, Damodar)
From Field Notes from a Waterborne Land, Bengal beyond the Bhadralok by Parimal Bhattacharya

There are two players, daughter's family, denoted by D, and son's family, denoted by S, and there are two periods, period 1 and period 2. At the beginning of period 1, D's income, $\widetilde{y_D}$, which is random and follows a commonly known distribution with distribution function F, gets realised. We assume, F has a positive density everywhere. Let y_D be the realised value of $\widetilde{y_D}$. This realised value, y_D, is observable only to D and not to S.

In period 1, D observes y_D, and then takes decisions on consumption (c), spending on daughter's education (m), amount to save for paying dowry later on (s), and her age of marriage (a). To assess the impact of a minimum age law, we assume that the law affects D's choice of age of marriage a. That is, D chooses a given the legal constraint on minimum age of marriage. So legal age becomes the lower bound for age of marriage.[8]

A possible marital alliance materialises in period 2. In period 2, S and D meet and S demands dowry d. If D accepts, marriage gets realised, otherwise not. In a developing country, daughter's marriage is almost a compulsion for her family, and presence of an unmarried daughter is often considered a burden[9]. So families prefer to marry daughters off whenever possible. In line with this, we assume that D accepts S's demand whenever $s \geq d$, that is D's savings s is greater than or equal to the dowry demand d. The timeline of the game is shown in Figure 1.

As we have a sequential game of incomplete information, the equilibrium strategy profile and belief system should satisfy the two requirements: (i) sequential rationality and (ii) consistency of beliefs with strategies. Here D chooses (c^*, m^*, a^*) by maximizing its utility given S's strategy d^* (which D can anticipate) and S chooses d^* by maximizing its utility given (c^*, m^*, a^*), and the belief F, where utilities of D and S are defined shortly. So the equilibrium $((c^*, m^*, a^*), d^*)$ with belief denoted by the distribution F of $\widetilde{y_D}$, satisfies the two requirements sequential rationality and consistency of beliefs with strategies.

Payoffs.

2.1. *D's payoff*

Let S demand dowry d in period 2. D's payoff U_D can be written as:

$$U_D = \begin{cases} u_D(c) + w(e(m,a),a), & \text{if } s \geq d \\ \overline{U_D}, & \text{otherwise.} \end{cases} \tag{1}$$

[8] We relax this assumption in Appendix E.

[9] For example, see Corno et al. (2020). In a developing country, an unmarried daughter is often considered a burden for her parents' family and the society often puts pressure on the daughter's family to get her married. At the extreme, there can be cases of social restrictions against a daughter's family for not getting their daughter married.

So U_D depends on (i) consumption c, (ii) daughter's education e, and (iii) her age a. Specifically, we assume, that the daughter's family D derives utility from consumption (c), daughter's education (e), but derives disutility from her age (a). This last assumption is plausible because of the social stigma associated with the presence of an unmarried daughter. In (1), $u_D(c)$ denotes D's utility from consumption c, where $u_D'(c) > 0, u_D''(c) < 0$ and $w(e(m,a),a)$ captures D's preference for daughter's education e and her age a. Given the fact that D derives utility from e and disutility from $a, w_e > 0, w_a < 0$. We assume diminishing marginal utility from the daughter's education e, that is, $w_{ee} < 0$. Also, we take $w_{ea} < 0$, D's marginal utility from e falls with a. Intuitively, higher the age at marriage of the daughter, that is, higher the period of her staying unmarried in her parents' home, lower is her family's marginal utility from her education. We assume, $e = e(m,a), e_m \geq 0, e_a \geq 0$, where m is spending on daughter's human capital, and a is her age of marriage, which also represents her years of education. Also, let $\overline{U_D}$ be D's reservation payoff if the match does not occur. Let d be the dowry that will be demanded from S in period 2 which D can infer in period 1. Given the importance of marriage for a daughter's family in a developing country, we assume that whenever D can afford the dowry demand, that is, whenever D's realised income y_D is greater than the dowry demand d (which D can observe beforehand), D keeps d amount for paying dowry, that is, it sets $s = d$. Hence disposable income is $(y_D - d)$. D allocates this $(y_D - d)$ between consumption (c) and spending in daughter's human capital (m). So we can rewrite (1) in terms of y_D, which gives:

$$U_D = \begin{cases} u_D(c) + w(e(m,a),a), & \text{if } y_D \geq d, \\ \overline{U_D}, & \text{otherwise.} \end{cases}$$

2.2. *S's payoff*

S's payoff U_S can be written as follows:

$$U_S = \begin{cases} u_S(c) + v(e,a), & \text{if marriage occurs} \\ \overline{U_S}, & \text{otherwise.} \end{cases} \tag{2}$$

So U_S depends on (i) consumption c, (ii) bride's education e, and (iii) her age a. Let, $u_S(c)$ be S's utility from consumption c, where $u_S(c)$ is concave. Also, let $v(e,a)$ capture S's preference for bride's education and age. Son's families tend to have preferences towards younger brides. As noted in Field and Ambrus (2008), reasons for such preference include the beliefs that younger brides are (a) more fertile, (b) more likely to lack sexual experience, and (c) easier to control. We capture this idea by assuming that a higher age of the bride gives a higher disutility to S, the son's family. So, we take $v_a < 0$.

S may or may not derive a positive utility from bride's education. An explanation for S having positive utility from bride's education could be due to better outcome for children when they have an educated mother. For example, Buchmann et al. (2023) show that children of educated mothers are healthier. However, Beuchamp et al. (2022) show that men dislike women's education (especially secondary education). They estimate that men do not value the education of their wives and actively substitute away from highly educated women. So, in that case, bride's higher education will bring disutility to the groom. To capture both the directions, we assume, v_e can be greater than, equal to or less than 0.

Finally, let $\overline{U_S}$ be the reservation payoff of S when marriage does not occur. So S's payoff is $[u_S(c) + v(e,a)]$ if marriage occurs, and $\overline{U_S}$ if marriage does not occur.

3. ANALYSIS

To solve the model, we start with S's problem in period 2. Let y_S be S's family income, which is exogenously given, and $y_f(e)$ be bride's income, with $y_f'(e) \geq 0$. So, post marriage, total consumption of the groom's family S is $c = (y_S + y_f(e) + d)$, the total amount of resources available to S. So using (2), S's utility can be written as:

$$U_S = \begin{cases} u_S\big(y_S + y_f(e) + d\big) + v(e,a), & \text{if marriage occurs} \\ \overline{U_S}, & \text{otherwise.} \end{cases}$$

Marriage occurs if $y_D \geq d$, otherwise not. S cannot observe y_D, but it is common knowledge that $\widetilde{y_D}$ follows a distribution with cdf F. Thus,

$$\Pr(\text{marriage}) = \Pr(y_D \geq d) = 1 - \Pr(y_D < d) = 1 - F(d).$$

So, S's expected utility from demanding any dowry d:

$$EU_S = \big[u_S\big(y_S + y_f(e) + d\big) + v(e,a)\big]\big(1 - F(d)\big) + \overline{U_S}\, F(d), \tag{3}$$

which S maximizes by choosing d.

Let the distribution F be such that a unique maximum given by the first order condition exists. In Section 4 we take specific distributional assumption to support this. So the FOC:

$$\frac{\partial EU_S}{\partial d} = 0, \tag{4}$$

$$\Rightarrow \big[\overline{U_S} - u_S\big(y_S + y_f(e) + d\big) - v(e,a)\big]\, F'(d) + \big(1 - F(d)\big)\, u_S{}'\big(y_S + y_f(e) + d\big) = 0. \tag{5}$$

Solving (5), we get the optimum d, d^*. This d^* is implicit here but we get closed form solution in a parameterized example in Section 4.

D can deduce this d^* while taking decision. We consider D's problem when $y_D \geq d^*$, that is, when its income is sufficient to cover the dowry demand. In the other case, when $y_D < d^*$, marriage does not take place and D gets the reservation payoff $\overline{U_D}$. We focus on the more interesting case with $y_D \geq d^*$. In this case D will save just enough to pay the dowry and not any more, so $s = d^*$ in this case. Hence $(y_D - d^*)$ is the disposable income of D, to be allocated between c, consumption and m, investment in daughter's education10.

So D faces the following budget constraint: $c + m \leq y_D - d^*$. Now let $\underline{a}$ denote the minimum legal age of marriage for women. To assess the impact of a change in legal minimum age of marriage for women $\underline{a}$, we assume that it is binding. Therefore, $a \geq \underline{a}$ (we relax this assumption in Appendix E). We take $m \geq 0$ as a constraint because human capital investment cannot be negative. Therefore D's problem:

$$\max_{c,m,a} \quad [u_D(c) + w(e(m,a),a)] \quad subject\ to \quad \begin{aligned} c + m &\leq y_D - d^*, \\ a &\geq \underline{a}, \\ m &\geq 0. \end{aligned} \tag{6}$$

Now a few words about the constraint $a \geq \underline{a}$. We do note that often in the developing countries, this constraint is not satisfied, and we often see underage marriages to be practiced there.[11] To incorporate that, in Appendix E we relax the constraint that the legal minimum age of marriage, $\underline{a}$ is binding. There we allow marriages of daughters below the legal minimum age, with a penalty if that gets detected. Using the parameterised example discussed in Section 4, we show, that our main result remains unaffected even if we allow marriages below the legal age $\underline{a}$.

Next we come back to D's problem given by (6). Suppose $a = \underline{a} + x$. So, given that there exists a legal minimum age of marriage $\underline{a}$, choosing a is equivalent to choosing x, where x is the number of years over and above the minimum legal age of marriage when the daughter is not married off. So $x \geq 0$. Given that marginal utility of money is positive, there is no unspent amount. Therefore,

$$c + m = y_D - d^* \;\Rightarrow\; c = y_D - d^* - m. \tag{7}$$

Therefore, the problem boils down to choosing two variables x and m. Assuming

[10] We assume away all other complications (albeit realistic) like more than one child, savings for other purposes etc.

[11] Using data from Demographic and Health surveys between 2003 and 2005, Chari et al (2017) reports that 27.1% of women between the ages of 15 and 19 are married in India (the legal minimum age is 18 years). Corresponding figures for other selected countries are: 46.1% in Bangladesh, 42% in Chad, 32.9% in Malawi, 50.4% in Mali, 38.2% in Mozambique and 31.7% in Nigeria.

the existence of interior maxima, the solutions are given by the following two FOCs:

$$\frac{\partial U_D}{\partial m} = 0,$$
$$\Rightarrow -u'_D(y_D - m - d^*)\left(1 + \frac{\partial d^*}{\partial m}\right) + w_e e_m = 0, \tag{8}$$

$$\frac{\partial U_D}{\partial x} = 0,$$
$$\Rightarrow -u'_D(y_D - m - d^*)\frac{\partial d^*}{\partial a} + w_e e_a + w_a = 0. \tag{9}$$

Solving (8) and (9) simultaneously, we get m^*, $x^*$and using them in (7), we get c^*, the equilibrium choices of D. Substituting m^*, x^* back into (5), we get d^*.

3.1. Impact of a Rise in Legal Minimum Age of Marriage for Women

Now we look into, how the equilibrium decisions $((c^*, m^*, x^*), d^*)$ change as $\underline{a}$ rises. Specifically, we focus on how D changes m^* following a rise in $\underline{a}$.

Now as D's decision making in period 1 takes S's decision (the dowry demand d) in period 2 as given (because D can infer it beforehand), we will first see how such a rise in $\underline{a}$ changes S's dowry demand d, and inferring that change in d beforehand, how D changes its optimal decision on daughter's human capital spending m. So next we focus on period 2, where S chooses dowry demand d, and see how that changes as $\underline{a}$, the legal minimum age of marriage for women, rises.

3.1.1. Period 2

Consider a rise in a from the initial equilibrium $((c^*, m^*, x^*), d^*)$. This raises $\underline{a} + x^* = a$. As bride's age a rises, there can be two opposite effects on S's utility. The first one is v_a, the direct effect of a rise in a on S's utility, which is negative. The second impact of a is the indirect effect coming through a potential increase in bride's education e due to a higher age at marriage. As a rises, e rises by e_a and thus U_S rises by $(v_e . e_a)$. How d changes depends on the relative strength of these two effects, as summarized in the following proposition.

Proposition 1

S's dowry demand d will rise with a rise in D's age a $(\frac{\partial d^*}{\partial a} > 0)$ if and only if:

$$|v_a| > v_e\ e_a - y'_f\, e_a\left[\frac{(1-F(d^*))}{F'(d^*)}\ u''_S\big(y_S + y_f(e) + d\big) - \ u'_S\ \big(y_S + y_f(e) + d\big)\right]. \tag{10}$$

Proof in Appendix A.

Note that (10) requires no restriction on the sign of v_e, it can be both positive or negative. If $v_e < 0$, that is if S gets negative marginal utility from the bride's education, then (10) is more likely to hold than in the case with $v_e > 0$.

For a better exposition, let us assume that $y_f'(e) = 0$ for the moment. We will be relaxing this soon. Now $y_f'(e) = 0$ if labour market opportunities for women are limited such that a higher education of a woman does not get translated into a higher earning. In that case Proposition 1 boils down to the following:

Corollary 1

$$\frac{\partial d^*}{\partial a} > 0 \Leftrightarrow |v_a| > v_e \ e_a, \tag{11}$$

where $|v_a|$ is S's absolute marginal disutility from bride's age a, and $v_e \ e_a$ is S's marginal utility from bride's education e. So, dowry demand rises with a rise in age when S's absolute marginal disutility from a higher bridal age is more than marginal utility from her education. In this case the net change in S's utility due to a rise in bride's age a will be negative. In order to overcome that utility loss, S demands a higher dowry. Given e_a, (11) holds when $|v_a|$, S's valuation for the bride's age-related traits is higher than v_e, its valuation for her education related traits.

Next we relax the assumption $y_f'(e) = 0$ and consider the general case with $y_f'(e) \geq 0$. Proposition 1 says, that, $\frac{\partial d^*}{\partial a} > 0$ if and only if the direct effect of a, which is the absolute marginal disutility from a higher age measured by $|v_a|$, is sufficiently large relative to the indirect effect, the marginal utility from bride's education, measured by $v_e \ e_a$. In other words, if age related traits of the bride are valued sufficiently high relative to her education related traits, then a rise in the bride's age will raise the dowry demanded by the son's family (S). This, and the implications of the second term in (10) are summarized in the following Observation below. Note that the second term in (10) is positive.

Observation 1. $\frac{\partial d^*}{\partial a} > 0$ is more likely if any combination of the following holds:

(1) $|v_a|$, S's absolute marginal disutility from bride's age rises,
(2) v_e, S's marginal utility from bride's education falls,
(3) e_a falls, that is a higher age implies a lower increase in bridal education,
(4) $y_f'(e)$ falls, that is, marginal impact of bride's education on her income falls.

Next we move to period 1 when D takes decisions on c^*, m^*, x^* taking S's demand d^* in period 2 as given, and see how a rise in $\underline{a}$ affects these decisions, especially the human capital investment decision.

3.1.2. Period 1

Equations (7), (8) and (9) give the equilibrium $c^*, m^*,$ and x^* decisions of D.

Recall that c^*, m^*, and x^* are parameterised by y_S, $\underline{a}, \overline{U}_S$, parameters of the distribution F of $\widetilde{y_D}$, and y_D, realised value of $\widetilde{y_D}$. Substituting (8) into (9), we get the following equilibrium relation between m and x:

$$\frac{\partial d^*}{\partial a} w_e e_m - \left(1 + \frac{\partial d^*}{\partial m}\right)(w_e e_a + w_a) = 0, \tag{12}$$

at (m^*, x^*). So, from (12) we can implicitly get $m^* = m^*(a^*)$, where $a^* = x^* + \underline{a}$.

Now, $\frac{\partial m^*(a^*)}{\partial \underline{a}} = \frac{\partial m^*}{\partial a^*}\frac{\partial a^*}{\partial \underline{a}}$. As the objective of a minimum age policy is to prevent early marriage by raising girls' age at marriage, we must have $\frac{\partial a^*}{\partial \underline{a}} > 0$ whenever the policy is effective. So, sign $\frac{\partial m^*}{\partial \underline{a}}$ = sign $\frac{\partial m^*}{\partial a^*}$.

We identify a sufficient condition for $\frac{\partial m^*}{\partial a^*} < 0$, whose implication is given in the following Proposition.

Proposition 2

Given that $\frac{\partial a^*}{\partial \underline{a}} > 0$, $\frac{\partial m^*}{\partial a^*} < 0,$ *and therefore* $\frac{\partial m^*}{\partial \underline{a}} < 0,$ *, is more likely to hold as* v_a *goes down.*

Proof The mathematical expressions of the Proposition along with the proof are given in Appendix B.

Intuitively, if S gets a huge marginal disutility from the bride's age a, it raises the dowry demand to a large extent to cover that utility loss as a^* rises. This forces D to cut back m^*. This is the perverse result that we wanted to highlight. This shows that with a rise in minimum legal age of marriage or women, parents may actually choose to spend less on her education.

To get closed form solutions we assume specific functional forms that satisfy our assumptions to characterize the solutions explicitly.

4. A PARAMETERISED EXAMPLE

Let, $u_S(c) = c,\ v(e,a) = \alpha e - \beta a;\quad \beta > 0,\ y_f(e) = \tau e;\quad \tau \geq 0,\ u_D(c) = \ln c$, $w(e,a) = \gamma \ln e - \delta a;\ \delta > 0,\ e(m,a) = m + a$. These are in line with our assumptions where,

(1) α is the marginal utility of S from bride's education, and thus α can be positive, negative or zero.

(2) β is the marginal disutility S gets from the bride's age, so $\beta > 0$.

(3) γ captures D's preference for daughter's education.
(4) δ is D's marginal disutility from daughter's age, so $\delta > 0$.
(5) τ is the marginal impact of bride's education on her income, so $\tau \geq 0$.

Also, it is common knowledge that $y_D \sim U[\underline{y}, \overline{y}]$. So, substituting these functional forms in (3), S's problem is to choose d^* by maximising:

$$EU_S = \frac{(d-\underline{y})}{(\overline{y}-\underline{y})}\overline{U_S} + \left[1 - \frac{(d-\underline{y})}{(\overline{y}-\underline{y})}\right]\left[y_S + y_f(e) + d + \alpha e - \beta a\right].$$

As EU_S is strictly concave in d, a unique maximum d^* is given by the first order condition, which we get by substituting the functional forms in (5). The solution d^* is given by the following:

$$d^*(m,x) = \frac{1}{2}\left[\overline{U_S} + \overline{y} - y_S + (\beta - \alpha - \tau)a - (\alpha + \tau)m\right]. \tag{13}$$

Given d^*, D's optimization problem (6) becomes:

$$\max_{c,m,x}[\ln c + \gamma \ln e - \delta a], \tag{14}$$

subject to $c + m \leq y_D - d^*(m,x),\ x \geq 0,\ m \geq 0$.

We assume parametric restrictions so that the two non-negativity constraints are satisfied and therefore drop them from our analysis. Given our assumptions, the objective function in (14) is concave and the constraint set corresponding to the first constraint, is convex, so there exists at least one solution to the problem and that is given by the first order conditions. Solving, we get the following:

Proposition 3.

The optimum choices of S and D are given by:

$$d^* = \frac{1}{2}\left(\overline{U_S} + \overline{y} - y_S\right) + \frac{\beta(1+\gamma)}{2\delta} + \frac{\beta\left(y_D - \frac{\overline{U_S}+\overline{y}-y_S}{2}\right)}{\beta-2} + \frac{\gamma(\beta-2)(\alpha+\tau)}{4\delta\left(1-\frac{\alpha+\tau}{2}\right)}, \tag{15}$$

$$m^* = \frac{\gamma\left(1-\frac{\beta}{2}\right)}{\delta\left(1-\frac{\alpha+\tau}{2}\right)} - \frac{(1+\gamma)}{\delta} + \frac{\left(y_D - \frac{\overline{U_S}+\overline{y}-y_S}{2}\right)}{\left(1-\frac{\beta}{2}\right)}, \tag{16}$$

$$x^* = \frac{(1+\gamma)}{\delta} + \frac{\left(y_D - \frac{\overline{U_S}+\overline{y}-y_S}{2}\right)}{\left(\frac{\beta}{2}-1\right)} - \underline{a}, \tag{17}$$

$$c^* = y_D - m^* - d^*(m^*, x^*), \tag{18}$$

$$e^* = \frac{\gamma\left(1-\frac{\beta}{2}\right)}{\delta\left(1-\frac{\alpha+\tau}{2}\right)}, \tag{19}$$

Proof in Appendix C.

Next we consider how $\underline{a}$ rise in a affects dowry demand from son's family (S) and consequently human capital spending (m) on the daughter in our example.

4.1. Period 2

We start from S's problem in period 2. Using the functional forms of the example in Proposition 1, we get the following:

Observation 2.

$$\frac{\partial d^*}{\partial a} > 0 \iff \beta > \alpha + \tau, \tag{20}$$

where β is the marginal disutility from bride's age for the son's family S, α is marginal utility S gets from her education, and τ captures the marginal impact of bride's education on her income. So when S's marginal disutility from bride's age outweighs the marginal utility, dowry demand rises with a rise in bride's age.

Given the change in S's decision on d^* as $\underline{a}$ rises, next we look into how D, observing the change in d^* that D will have to face in period 2, adjusts its optimum decision on m, human capital spending on the daughter. So, we move to period 1, where D takes decisions on m, x, and c.

4.2. Period 1

We start from the solution to D's problem (14) in the parameterised example. The solutions $((c^*, m^*, x^*), d^*)$ are given by (15)-(18).

Now, given that there exists this legal constraint $\underline{a}$, and a^* cannot go below that, so for D already having $a^* = \underline{a}$, that is $x^* = 0$, reducing x further is not possible. So, with a rise in $\underline{a}$, that D will have to raise a^*. Therefore $\frac{\partial a^*}{\partial \underline{a}} > 0$ whenever D already has $a^* = \underline{a}$ prior to the legal change. Again, from Proposition 1 and its counterpart in our example given by Observation 2, we find that $\frac{\partial d^*}{\partial a} > 0$ whenever S's preference against bride's age is strong enough relative to her education.

Assuming the condition in Proposition 1 (and in Observation 2, in the context of our parameterised example) is true, whenever a minimum age of marriage law comes effective in the sense that it actually raises the age at marriage, son's family demands a higher dowry because of that higher bridal age. Upon anticipation of that, daughter's family is forced to cut spending on her education. This can be seen from the following relation between equilibrium m^* and a^* in our example:

$$m^* = \frac{\gamma\left(1-\frac{\beta}{2}\right)}{\delta\left(1-\frac{\alpha+\tau}{2}\right)} - a^*. \tag{21}$$

From this, we get the following observation:

Observation 3

$\frac{\partial m^*}{\partial \underline{a}} < 0$ whenever $\frac{\partial a^*}{\partial \underline{a}} > 0$.

Now government enacts a minimum age of marriage law primarily to prevent early marriage of girls by raising their age at marriage. So, whenever the purpose of such a law is fulfilled, that is the actual age of marriage rises following the law, the optimum investment on the daughter is going to fall. This is because of the rise in future dowry payment which the daughter's family can anticipate while deciding m^*.

5. CONCLUSION

In a place where the poverty level was as high as 75 per cent and literacy as low as 20, where the food people grew in their fields barely sustained them for three months a year, a boy or a girl returning home with a bundle of sal leaves or firewood from the jungle was more real, and held more value, than one returning from school. In a place where life was lived from moment to moment, from hunger to hunger, vidya [education] was an obscure investment in a hazy future. Here, the only genuine thing a child brought back from school was tikin mandijom [midday meal] - a quantity of food saved at home, that went to feed another belly. ... 'Many families here with two children will send one to school and the other to the forest ... If it's a girl, they'll keep her at home for household work.'

(Page 132 - 133, A Chain Tale, Simlipal)

From Field Notes from a Waterborne Land, Bengal beyond the Bhadralok, by Parimal Bhattacharya.

Minimum age of marriage legislation for women has been a strategy for various countries to reduce the ill-practice and consequences of early marriage. In this paper, we show that such a policy, despite having some positive consequences for some countries (as discussed in the Related Literature subsection), can have a serious drawback. It can reduce a family's incentive to spend on daughter's human capital. In a dowry-paying society, such a policy can lead to an increase in dowry and thus can actually force daughters' parents to spend less on their human capital in order to pay that increased dowry.

We model this using a simple 2-period game of incomplete information, where first period corresponds to the daughter's human capital accumulation, and the second period corresponds to her marriage. We consider a general setup followed by a parameterised example to generate comparative static results on daughter's human capital investment, age of marriage and son's family's dowry demand to establish our conjecture.

Our model is a short run model. One interesting area of future research could be a look into inter-generational aspect of such a law. Over time, if the social norm about ideal age of marriage for women changes as a result of such a law, that is, if the social minimum coincides with the legal minimum, then the law may not induce an increase in dowry and thus may not reduce parents' spending on daughter's human capital. In that case, despite our short run finding that investment on the daughter can go down, the long run effect can be desirable.

APPENDIX

Appendix A. Proof of Proposition 1

Proof. S's problem:

$$\max_d \; EU_S = \left[u_S\left(y_S + y_f(e) + d\right) + v(e,a)\right]\left(1 - F(d)\right) + \overline{U_S}\, F(d).$$

Assuming interior optimum, FOC:

$$\frac{\partial \; EU_S}{\partial d} = 0$$

$$\Rightarrow \left[\overline{U_S} - \; u_S\left(y_S + y_f(e) + d\right) - v(e,a)\right] F'^{(d)} + \left(1 - F(d)\right) u_S'^{(y_S + y_f(e) + d)} = 0$$

Solving, we get $d^* = d^*(\, m, a, y_S, \overline{U_S}\,)$. From this:

$$\frac{\partial d^*}{\partial a} = \frac{F'(d^*)\left(v_e e_a + v_a + \; u_S' \, y_f' e_a\right) \; -(1 - F(d^*))\, u_S'' \, y_f' e_a}{\left[\overline{U_S} - u_S\left(y_S + y_f(e) + d\right) - v(e,a)\right] F''(d^*) - 2\, F'(d^*)\, u_S' + (1 - F(d^*))\, u_S''}. \tag{22}$$

Given that d^* is the unique interior maximum,

$$\frac{\partial^2 \; EU_S}{\partial d^2} < 0, \tag{23}$$

at $d = d^*$. This is the expression we have here in the denominator, so that is negative.

So, $\frac{\partial d^*}{\partial a} > 0$ if and only if the numerator is negative. i.e.,

$$v_a + v_e e_a < y_f' e_a \left[\left(\frac{1-F(d^*)}{F'(d^*)} \right) u_S'' - u_S' \right].$$

In other words, $\frac{\partial d^*}{\partial a} > 0$ if and only if v_a (which is negative), is sufficiently high in magnitude relative to v_e. Formally,

$$|v_a| > v_e \ e_a - y_f' \, e_a \left[\frac{(1-F(d^*))}{F'(d^*)} \ u_S'' - \ u_S' \right]$$

where v_a and v_e represents marginal disutility and marginal utility from age and education of the bride respectively. Therefore, we prove the proposition.

Appendix B. Proof of Proposition 2

Proof. Assuming that $\frac{\partial^2 d^*}{\partial m^2}, \frac{\partial^2 d^*}{\partial a^2}, \frac{\partial^2 d^*}{\partial m \, \partial a}$ are small in magnitudes and thus can be ignored, we get from (12) that $\frac{\partial \, m^*}{\partial a^*}$ is given by the following:

$$-\frac{w_e\left[\frac{\partial d^*}{\partial a} e_{ma} - \left(1+\frac{\partial d^*}{\partial m}\right) e_{aa}\right] + w_{ee} e_a\left[\frac{\partial d^*}{\partial a} e_m - \left(1+\frac{\partial d^*}{\partial m}\right) e_a\right] + w_{ea}\left[\frac{\partial d^*}{\partial a} e_m - \left(1+\frac{\partial d^*}{\partial m}\right) 2\, e_a\right] - \left(1+\frac{\partial d^*}{\partial m}\right) w_{aa}}{w_e\left[\frac{\partial d^*}{\partial a} e_{mm} - \left(1+\frac{\partial d^*}{\partial m}\right) e_{ma}\right] + w_{ee} e_m\left[\frac{\partial d^*}{\partial a} e_m - \left(1+\frac{\partial d^*}{\partial m}\right) e_a\right] - \left(1+\frac{\partial d^*}{\partial m}\right) w_{ea} e_m}.$$

So, $\frac{\partial \, m^*}{\partial a^*} < 0$ if the following two conditions hold:

$$\begin{aligned} & w_{ee} e_a \left[\frac{\partial d^*}{\partial a} e_m - \left(1 + \frac{\partial d^*}{\partial m}\right) e_a \right] + w_{ea} \left[\frac{\partial d^*}{\partial a} e_m - \left(1 + \frac{\partial d^*}{\partial m}\right) 2\, e_a \right] \\ & < -w_e \left[\frac{\partial d^*}{\partial a} e_{ma} - \left(1 + \frac{\partial d^*}{\partial m}\right) e_{aa} \right] + \left(1 + \frac{\partial d^*}{\partial m}\right) w_{aa}, \end{aligned} \tag{25}$$

$$\begin{aligned} & w_{ee} e_m \left[\frac{\partial d^*}{\partial a} e_m - \left(1 + \frac{\partial d^*}{\partial m}\right) e_a \right] \\ & < - w_e \left[\frac{\partial d^*}{\partial a} e_{mm} - \left(1 + \frac{\partial d^*}{\partial m}\right) e_{ma} \right] + \left(1 + \frac{\partial d^*}{\partial m}\right) w_{ea} e_m. \end{aligned} \tag{26}$$

(25) and (26) directly follow from (24). Now, to see when $\frac{\partial \, m^*}{\partial a^*} < 0$ is more likely, first we note that both (25) and (26) are more likely to hold as $\Delta = \left[\frac{\partial d^*}{\partial a} e_m - \left(1 + \frac{\partial d^*}{\partial m}\right) e_a \right]$ rises, where:

$$\Delta = -e_a + \frac{F'\ v_a e_m}{[\overline{U_S} - u_S(y_S + y_f(e) + d) - v(e,a)]\ F'' - 2\ F'\ u_S' + (1-F)\ u_S''}. \tag{27}$$

Now given that we are looking at changes in the equilibrium values, we are evaluating all the expressions in equilibrium. So, the denominator in the second term of (27) is negative. From (27), simple differentiation gives: $\frac{\partial \Delta}{\partial v_a} < 0$ and therefore it is more likely to have $\frac{\partial\ m^*}{\partial a^*} < 0$ as v_a falls.

Appendix C. Proof of Proposition 3

Proof. Given our assumptions, the objective function in (14) is concave and the constraint set corresponding to the first constraint, is convex, so there exists at least one solution to the problem and that is given by the first order conditions:

$$\frac{\partial U_D}{\partial m} = 0 \Rightarrow -\frac{\left(1-\frac{\alpha+\tau}{2}\right)}{(y_D - m - d^*)} + \frac{\gamma}{a+m} = 0$$

$$\frac{\partial U_D}{\partial x} = 0 \Rightarrow -\frac{(\beta-\alpha-\tau)}{2\ (y_D - m - d^*)} + \frac{\gamma}{a+m} - \delta = 0$$

Solving simultaneously, we get:

$$m^* = \frac{\gamma\left(1-\frac{\beta}{2}\right)}{\delta\left(1-\frac{\alpha+\tau}{2}\right)} - \frac{(1+\gamma)}{\delta} + \frac{\left(y_D - \frac{\overline{U_S}+\overline{y}-y_S}{2}\right)}{\left(1-\frac{\beta}{2}\right)}, \tag{28}$$

$$x^* = \frac{(1+\gamma)}{\delta} + \frac{\left(y_D - \frac{\overline{U_S}+\overline{y}-y_S}{2}\right)}{\left(\frac{\beta}{2}-1\right)} - \underline{a}. \tag{29}$$

As the first constraint in (14) has to be binding at the optimum,

$$c^* = y_D - m^* - d^*(m^*, x^*)$$

Substituting m^*, x^* and c^* in (13), the equilibrium dowry demand made by S is given by:

$$d^* = \frac{1}{2}\left(\overline{U_S} + \overline{y} - y_S\right) + \frac{\beta\ (1+\gamma)}{2\delta} + \frac{\beta\left(y_D - \frac{\overline{U_S}+\overline{y}-y_S}{2}\right)}{\beta-2} + \frac{\gamma\ (\beta-2)(\alpha+\tau)}{4\delta\left(1-\frac{\alpha+\tau}{2}\right)}.$$

Also, using (16) and (17), $e^* = \frac{\gamma\left(1-\frac{\beta}{2}\right)}{\delta\left(1-\frac{\alpha+\tau}{2}\right)}$.

Appendix D. Comparative Statics for e^*, m^*, x^*, d^*

Next, we enlist some of the comparative static results which are particularly interesting for our purpose.

Observation 4. For e^*, daughter's education level in equilibrium, we get :

(1) $\frac{\partial e^*}{\partial \tau} > 0$, that is, e^* increases as women's earning prospect rises ,

(2) $\frac{\partial e^*}{\partial \alpha} > 0$, so e^* increases as S's preference for bride's education rises,

(3) $\frac{\partial e^*}{\partial \beta} < 0$, so as S's marginal disutility from bride's age increases, e^* falls,

(4) $\frac{\partial e^*}{\partial \gamma} > 0$ if $\beta < 2$, that is, e^* increases with γ, if β, S's marginal disutility from bride's age is not high enough. So if marginal disutility of bridal age for S is too high, then even with a rise in D's own preference for daughter's education, her education level falls,

(5) $\frac{\partial e^*}{\partial \delta} < 0$, so as D's marginal disutility from age of the daughter increases, her education level falls.

Observation 5. In equilibrium, investment in daughter's education level m^*:

(1) increases as women's earning prospect rises ($\frac{\partial m^*}{\partial \tau} > 0$),

(2) increases as S's preference for bride's education rises ($\frac{\partial m^*}{\partial \alpha} > 0$),

(3) increases with D's income y_D if $\beta < 2$, that is, S's marginal disutility from bride's age is not high enough ($\frac{\partial m^*}{\partial y_D} > 0$ if $\beta < 2$), also,

(4) $\frac{\partial m^*}{\partial \gamma} > 0$ if $\beta < \alpha + \tau$.

Observation 6. For x^* , we have the following:

(1) $\frac{\partial x^*}{\partial y_D} > 0$ if $\beta > 2$. So, y_D and x^* are positively related when $\beta > 2$. The idea is as follows: when β is high, the rise in S's dowry demand due to a rise in age a is high, and thus a higher income y_D is required to afford a higher x^* (and therefore a higher equilibrium age at marriage a^*).

(2) Also, $\frac{\partial x^*}{\partial \beta} < 0$, that is, as S becomes more intolerant towards a higher age of the bride, D marries off the daughter more quickly.

(3) Similarly, $\frac{\partial x^*}{\partial \delta} < 0$, that is, as D itself disfavors an older unmarried daughter more, it marries her off at a lower age.

(4) But $\frac{\partial x^*}{\partial \gamma} > 0$, that is if D's preference for daughter's education increases, then her age at marriage increases, something we can expect.

(5) $\frac{\partial x^*}{\partial u_S} > 0$ if $\beta < 2$.That is, when β, S's marginal disutility from bride's

age is low enough, an increase in $\overline{u_S}$ can not deter D from increasing age at marriage in the equilibrium. So even with a rise in $\overline{u_S}$, D raises x^*.

Observation 7. Next we look at comparative statics of d^*.

(1) $\frac{\partial d^*}{\partial y_D} > 0$ if $\beta > 2$. So, when bride's family income rises, S demands a higher dowry if β is sufficiently high.

(2) Similarly, $\frac{\partial d^*}{\partial y_S} > 0$ if $\beta > 2$.

(3) $\frac{\partial d^*}{\partial \overline{u_S}} > 0$ if $\beta < 2$. We have seen that $\frac{\partial x^*}{\partial \overline{u_S}} > 0$ if $\beta < 2$, and as x^* rises, S asks for s higher dowry as it prefers a younger bride.

(4) Also, we find that $\frac{\partial d^*}{\partial \tau} < 0$, that is, as bride's income prospect gets better, S demands a lower dowry. The idea behind this is the following: here, by dowry we mean a one-time payment at the time of marriage. However, if the bride earns more, it leads to a higher flow of income for the husband's family S. So when that is the case, S asks for a lower upfront payment as it can be compensated by a higher income flow in future.

(5) $\frac{\partial d^*}{\partial \alpha} < 0$, that is, as S's preference for a more educated bride increases, it demands a lower dowry.

(6) $\frac{\partial d^*}{\partial \gamma} > 0$ if $\frac{\partial d^*}{\partial a} > 0$. Basically, As, γ rises, a^* rises ceteris paribus, as we have already seen. So, if dowry demand rises with that, then a rise in γ translates into a rise in d^*.

Appendix E. Model without Legal Age Constraint

As in Section 4, here also we consider the same functional forms, so:

$u_S(c) = c$, $v(e,a) = \alpha e - \beta a$; $\beta > 0$, $y_f(e) = \tau e$; $\tau \geq 0$, $u_D(c) = \ln c$, $w(e,a) = \gamma \ln e - \delta a$; $\delta > 0$, $e(m,a) = m + a$, and it is common knowledge that $y_D \sim U[\underline{y}\ ,\ \overline{y}\ ]$. $\underline{a}$ denotes the legal minimum age at marriage for women. D has to pay a penalty C if an underage marriage is detected. Let the probability of detection be p, defined as follows:

$$p = \begin{cases} p(\underline{a} - a), & \text{if } a < \underline{a} \\ 0, & \text{otherwise.} \end{cases}$$

So, the expected cost of an underage marriage is: $p(\underline{a} - a)C$. We assume, this cost increases at an increasing rate as $(\underline{a} - a)$ increases, that is, as the actual age at marriage a falls shorter of the legal minimum $\underline{a}$. In other words, $p'(\underline{a} - a) > 0$, $p''(\underline{a} - a) > 0$.

Now, if bride's age is less than $\underline{a}$ and that is detected, then the marriage cannot materialise. So, the possibility of detection will affect the probability of marriage for S and hence S's expected payoff. Let X denote the event of $y_D \geq d$, Y be the event that $a \geq \underline{a}$, and Z be the event that an underage marriage is not detected. So, probability of marriage is : Pr $[\,(X \cap Y) \cup (X \cap Y^c \cap Z)]$. Let a follows distribution g with CDF G. We assume that y_D and a are distributed independently. Given that, the probability of marriage for S:

$$\Pr(\text{marriage}) = \frac{(\bar{y} - d)}{(\bar{y} - \underline{y})}\left[1 - p(\underline{a} - a)G(\underline{a})\right]$$

Using (3), S's problem is to choose d^* by maximising:

$$EU_S = \frac{(\bar{y} - d)}{(\bar{y} - \underline{y})}\left[1 - p(\underline{a} - a)G(\underline{a})\right]\left[y_S + y_f(e) + d + \alpha e - \beta a\right] + \left[1 - \frac{(\bar{y} - d)}{(\bar{y} - \underline{y})}\left[1 - p(\underline{a} - a)G(\underline{a})\right]\right]\overline{U_S}.$$

Solving we get $d^*(m, x)$ which is the same as we got in (13). Given $d^*(m, x)$, next we look into D's problem. We take the expected cost of an underage marriage as a linear deduction from D's payoff. Everything else remain the same as in Section 4. So, D's problem now becomes:

$$\max_{c,m,x} \quad [\ln c + \gamma \ln e - \delta a] - p(\underline{a} - a)C, \; s.t. \; c + m \leq y_D - d^*(m, x); \; m \geq 0.$$

The first constraint will be binding at the optimum. Now, as U_D is strictly concave, and the constraint set is convex, so the problem above has a unique solution given by the following first order conditions:

$$\frac{\partial U_D}{\partial m} = 0 \Rightarrow -\frac{\left(1 - \frac{\alpha + \tau}{2}\right)}{(y_D - m - d^*)} + \frac{\gamma}{a + m} = 0,$$

$$\frac{\partial U_D}{\partial x} = 0 \Rightarrow -\frac{(\beta - \alpha - \tau)}{2\,(y_D - m - d^*)} + \frac{\gamma}{a + m} - \delta + p'(\underline{a} - a)C = 0.$$

In equilibrium, x^*, and therefore a^* (where $a^* = a + x^*$) is given by the following equation:

$$\left(\frac{\beta}{2} - 1\right)\left[\frac{a}{1+\gamma} - \frac{1}{\delta - p'(\underline{a} - a)C}\right] = \frac{y_D - \frac{\overline{U_S} + \bar{y} - y_S}{2}}{1+\gamma},$$

which shows that $\frac{\partial a^*}{\partial \underline{a}} > 0$.

Now the equilibrium relation between m^* and x^* is given by:

$$m^* = \frac{\gamma\left(1-\frac{\beta}{2}\right)}{\delta\left(1-\frac{\alpha+\tau}{2}\right)[\delta - p'(\underline{a}-a)C]} - a^*,$$

which gives: $\frac{\partial m^*}{\partial a^*} < 0$. So, we see that as $\underline{a}$ rises, D's optimum choice a^* of age at marriage rises (since $\frac{\partial a^*}{\partial \underline{a}} > 0$), and therefore m^* falls (since $\frac{\partial m^*}{\partial a^*} < 0$).

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