Marrying Young: The Surprising Effect of Education

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Abstract

We study the impact of an increase in women's education on their age at marriage. Exploiting a regression discontinuity for a large-scale school construction program in India, we find that the program increases women's education by 0.4-1 year, but decreases their age at marriage by 0.75-1.55 years for a one-year increase in education. Next, we find that post-marriage, educated women experience less domestic violence, better health care access, lower fertility levels, and a wealthy match in the marriage market. Finally, we find a 50 percent increase in women's wages leads to a delay in age at marriage by 0.1 years.

Keywords: Education, marriage market, age at marriage
JEL Codes: J12, J16, I2, I24, I28

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What is the effect of education on women's age at marriage? This question is particularly important as early marriage is still a common practice in many developing countries. In India, nearly one-third of women aged 20-24 were married before the legal age of 18 (DHS, 2017). Early marriage can have negative consequences on women's health and economic outcomes (Chari et al., 2017; Corno, Hildebrandt, & Voena, 2020; Field & Ambrus, 2008; Jensen & Thornton, 2003). Education can increase women's age at marriage through knowledge, changes in preferences and wages (Becker, 1973; Chiappori, Iyigun, & Weiss, 2009; Heath & Mobarak, 2015; Jensen, 2012). However, the positive association between education and age at marriage is not obvious under conditions of marriage market imperfections, rigid social norms and low labor market returns for women (Biswas & Das, 2021; Buchmann et al., 2021; Lavy & Zablotsky, 2011).

In this paper, we estimate how an increase in women's education affects their age at marriage in the context of India. There are two main reasons why India provides an interesting case to study this association. First, marriage is near universal, typically arranged by parents in a traditional marriage market (Anukriti & Dasgupta, 2017). Second, even though in the last two decades India has witnessed a phenomenal increase in the average years of education for women there are no substantial changes in the labor market outcomes for women (Jayachandran, 2021; Klasen & Pieters, 2015). Therefore, it is important to understand how the increase in education affects women's returns in a marriage market with rigid beliefs and preferences when there are low gains in the labor market.

To causally estimate the relationship between women's education and their timing of marriage, we exploit the quasi-random variation in primary schooling induced

by a large-scale education program in India, District Primary Education Program (DPEP). DPEP targeted low literacy districts by building schools, hiring teachers, and upgrading infrastructure (Jalan & Glinskaya, 2002). We exploit a discontinuity in the probability of receiving DPEP around the female literacy cut-off similar to the regression discontinuity framework developed by Khanna (2023).

We first show that the program leads to an increase in women's education of around 0.4-1 year. Our estimates are comparable to Sunder (2020), who also find that the program increased women's education by around 0.8 years. Another study by Akresh, Halim, and Kleemans (2023) on the long-term effect of the school construction program in Indonesia, finds an average effect of 0.46 years of education for women in the treated district. The study by Duflo (2001) finds an increase of 0.19 years. We are estimating a local average treatment effect (LATE) for those districts around the cut-off who were induced into taking the program as opposed to the average treatment effect. This could explain the slightly larger effect in our study.

Next, we estimate the impact of an increase in education on age at marriage using the female literacy cut-off indicator as an instrument for education. Our instrument is valid only in the close neighbourhood of the cut-off.[1] The identifying assumption is that those districts that were induced to get the program (as indicated by the female literacy cut-off variable) are comparable to those who just missed getting the program by a small margin. We find that one year increase in women's education leads to a fall in their age at marriage by 0.75-1.55 years. The average age at marriage in comparable districts is 18.76. This suggests that one year increase

[1]There are 112 districts within the centered female literacy cut-off range of plus-minus 5.13 percent. Out of these 63 are below and 49 are above the cut-off.

in women's education reduces the average age at marriage to 18.01 years. We also find that with a one-year increase in education the probability of a woman marrying before the legal age of 18 increases by 23 percent. Our results are contrary to the existing evidence that finds a positive association between education and age at marriage (Breierova & Duflo, 2004; Carmichael, 2011; Gyimah, 2009)[2].

We provide a conceptual framework for the negative association between education and age at marriage in our context using a transferable utility, unitary household model (Chiappori, 2020; Low, 2014). Men prefer educated and young brides. In countries with low returns to female education in the labor market, the preference for an educated bride is explained by the important role of mothers in the intergenerational transmission of human capital (Behrman et al., 1999; Rosenzweig & Wolpin, 1994). While women prefer grooms with high incomes. Women's families invest in their daughter's education mainly to find a high-quality groom in the marriage market given low perceived returns in the labor market. According to Adams and Andrew (2019), parents believe that the chance of a poorly educated daughter receiving a marriage offer from a high-quality groom with a government job is very low. Given men's preferences, educated women benefit by entering the marriage market early. Our conceptual framework implies educated women receive a positive benefit from the match or higher surplus post-marriage.

To check this implication empirically, we analyze if education leads to a stable match and if there is an improvement in women's post-marriage well-being indicators. We use post-marriage domestic violence to signal stability.[3] We find a drop

[2]In this study, education implies primary education. Hence, the mechanical positive relation between higher education and age at marriage does not apply

[3]In the literature, divorce is used to indicate an unstable match. India has the lowest divorce rates in the world, (Jacob & Chattopadhyay, 2016), therefore, we cannot use it as an indicator of stability.

in the domestic violence experienced by women due to an increase in education, though not significant.[4] We also find that educated women are more likely to be matched in the high-wealth percentile households and report an increase in hospital deliveries, access to antenatal care, and contraceptive use by 10, 9, and 23 percent respectively. Fertility also declines by 11 percent. Overall, these indicators suggest an improvement in the post-marriage well-being of educated women.

Next, we explore if the availability of an outside option can lead to a delay in marriage. We find that the negative effect of education on age at marriage is more pronounced for women who live in districts with low wage rates (a proxy for the opportunity cost of marriage) compared to those with high wage rates. We interact district-wise average female wages with the DPEP cut-off indicator. Using reduced form estimates, we find that a 200 rupee increase in women's wages (i.e. 50 percent of the weekly district wage level) leads to an increase in age at marriage for educated women by 0.5 years compared to less educated women.

Finally, we look for heterogeneous effects by the level of women's education. We show that the negative association between education is larger at the median and higher levels of education. We perform IV quantile regression to study the distributional impact of education on age at marriage using the framework of Kaplan and Sun (2017). We find that there is a fall in age at marriage for the mean and median level of education (8 years). At higher education quantiles there is a further decrease in age at marriage. This implies that the negative relationship between education and age at marriage is mainly driven by women who have completed at least primary education (more than 5 years of education).

[4]However, when we check the impact of the DPEP program on domestic violence, we find there is a significant fall in domestic violence.

This study adds to the rich literature on factors that influence the timing of marriage and more specifically the literature on the effect of an increase in education on the timing of marriage (Ashraf et al., 2020; Buchmann et al., 2021; Corno, Hildebrandt, & Voena, 2020; Goldin & Katz, 2002). There exists mixed evidence on the causal effect of female education on age at marriage. On one hand, earlier literature finds a positive association between education and age at marriage (Breierova & Duflo, 2004; Brien & Lillard, 1994; Carmichael, 2011; Grépin & Bharadwaj, 2015; Gyimah, 2009; Kırdar, Dayıoğlu, & Koç, 2018). However, Kırdar, Dayıoğlu, and Koç (2018) finds that the human capital effect of more schooling on the marriage decisions of women might be short-lived. Also, the positive association between women's education and age at marriage is not obvious under conditions of marriage market imperfections, rigid social norms, and low labor market returns for women (Biswas & Das, 2021; Ikamari, 2005; Lavy & Zablotsky, 2011). Our paper adds to this literature by highlighting the role of preferences in the traditional marriage market and low returns for women in the labor market. Our results imply in such a context increasing education alone might not help in delaying the age at marriage for women.

We provide further evidence of positive assortative matching on education for women in India which is in line with evidence from both developed and developed countries (Attanasio & Kaufmann, 2017; Borkotoky & Gupta, 2016; Chiappori, Dias, & Meghir, 2018; Keskar, 2021; Lefgren & McIntyre, 2006; Smits & Park, 2009). Finally, we add to the rich literature on marriage markets in developing countries (Anderson & Bidner, 2015; Anukriti & Dasgupta, 2017; Banerjee et al., 2013; Beauchamp, Calvi, & Fulford, 2017; Chiplunkar & Weaver, 2021; Dhar,

2021). A large body of this literature focuses on the role of caste, marriage payments (dowry in the case of India), and the heterogeneity in the quality of grooms (using men's education/earnings as a proxy) to understand the marriage markets in India. We provide empirical evidence on how changes in bride quality (using women's education as a proxy) affect her outcomes in the marriage market. Using the exogenous increase in women's education we show more educated women earn a premium in the marriage market as explained by improvement in joint post-marriage surplus indicators.

The rest of the paper proceeds as follows. Section 1 provides a background. Section 2 describes the data. Section 3 and 4 provides the estimation strategy and results respectively. Section 5 provides a conceptual framework for the results. Section 8 includes robustness checks and section 9 concludes the paper by discussing the key findings and steps ahead.

1 Background

Over the past few decades, India has heavily invested in programs to increase women's schooling. As a result, the country has witnessed significant progress in access to education. The average female education for women in the age group 25-49 increased from around 3.2 years in 1992 to 6.4 years in 2014. However, when it comes to age at marriage the median for this cohort has only changed by one year over two decades (from 17 in 1992 to 18 years in 2014). Using DHS data from 1992-93 and 2014-15 we look at the relationship between education and age at marriage for all women in the age group 25-49 years. In Figure 1 we plot

the predicted conditional means from a regression of age at marriage on education for females in the age group 25-49. One can notice the major improvements in age at marriage have come from women who have less than 8 years of education (elementary grades). For women who have more than 8 years of education, there is not much change in the age at marriage over the past 20 years (the two lines converge) even though there is an increasing proportion of women who are finishing elementary education (as depicted by the histogram). Why has the average age at marriage not changed for more educated women in India? This paper tries to shed light on this puzzle using a natural experiment.

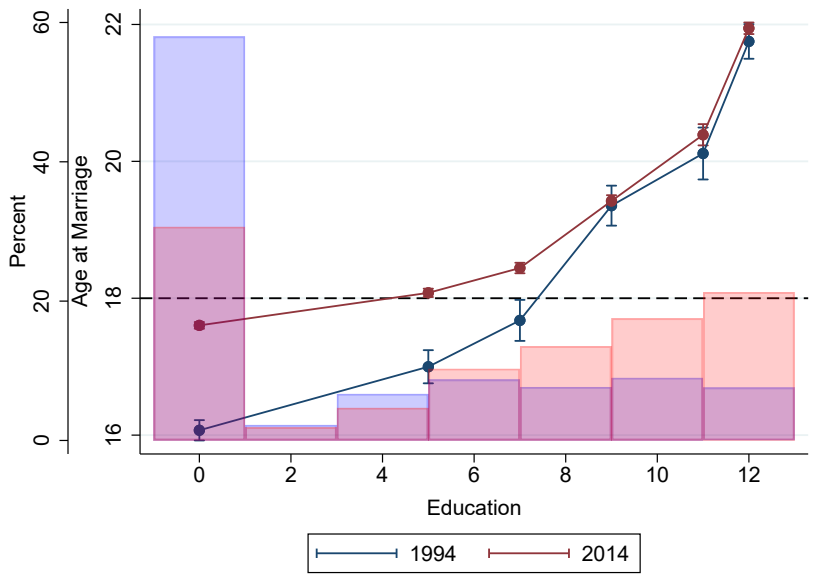

Figure 1 Age at marriage by years in education. This line plots the predicted conditional means from a regression of age at marriage and years of education with district-fixed effects. The histogram shows the population distribution by education level over the two time periods. The horizontal dotted line represents the legal age for marriage for women in India.

1.1 District Primary Education Program (DPEP)

The District Primary Education Program (DPEP) is one of the largest donor-assisted programs launched by the Government of India in the year 1994. The scheme was run in partnership with the central government, the state governments, and external donor agencies. The main objectives of the program were to increase access and quality of primary education and reduce gender and socio-economic inequality. Financing of the program was based on an 85:15 ratio with 85 percent given as a grant to the states by the central government (in partnership with international development agencies, World Bank, ECU, DFID, and UNICEF) and 15 percent contributed by the state governments. In order to avoid crowding out of government investment in elementary education, the state governments had to maintain at least their existing levels of expenditure on elementary education. Overall, the project leads to an increase in the total allocation by the government for elementary education by about 17.5 to 20 percent.

Apart from civil works the program interventions ranged from enrollment drives, community mobilization campaigns, and establishment of academic resource centers, to in-service teacher training, textbook, and curriculum renewal (Sipahimalani-Eao & Clarke, 2003). The program also focused on decentralized management of elementary education with districts as the main administrative unit. To ensure that a large part of the funds was spent directly on quality improvements, strict guidelines were laid regarding the proportions spent on civil works (24 percent) and management costs (6 percent) (Pandey, 2000). According to the 16th Joint Review mission (MHRD, 2002), DPEP covered around 51.3 million children and 1.1 million teachers in the school system. By the year 2002 around 86,850 new schools and 83,500

alternative school centers were set up.

An important feature of the program was that it was targeted at districts with poor educational outcomes. There were two main criteria that were used to select districts under the DPEP. First, the districts with a female literacy rate below the national average of 39.3 were selected, and second, districts where the total literacy campaigns were successful. However, by 1994, the total literacy campaign had been implemented in almost all districts in India. Hence, the main selection criterion for DPEP was the national average female literacy rate. The program was introduced in four phases across the country. The total number of districts covered by all DPEP phases (1994-2002) was 242 (273 with bifurcated districts) covering 18 states of India.

Initial evidence showed that the program helped in improving access to primary education and progression into higher levels of education beyond primary (Jalan & Glinskaya, 2002). More recent studies provide evidence of the policy on education levels after the completion of the program. Azam and Saing (2017) use the difference-in-difference method to estimate the impact of the policy on the probability of completed primary education and years of schooling. While Khanna (2023) uses a Regression Discontinuity Design to estimate the general equilibrium (GE) effect of the policy on education and labor market outcomes. Both studies find a positive effect of the program on the years of schooling.

2 Data

For our analysis, we combine National Family and Health Survey (NFHS-4, 2015-16), the NSS employment and unemployment survey (2005), the District Information on Systems in Education (DISE 2005), and Primary Census Abstracts 1991 (Adukia, Asher, & Novosad, 2020; Jayachandran, 2017). The NFHS is a nationally representative survey carried out under the aegis of the Ministry of Health and Family Welfare (MoHFW), Government of India. The survey includes data on fertility, health, and family welfare for the country at the individual level. The sample is generated using the stratified two-stage sampling method with the 2011 census as the sampling frame. Primary Sampling Units consist of villages in rural areas and Census Enumeration Blocks (CEBs) in urban areas (DHS, 2017). For our analysis, we use the Women's Questionnaire with detailed information on women's background characteristics (age, literacy, schooling, religion, caste/tribes), marriage and fertility decisions. A total of 723,875 eligible women aged 15-49 were identified for individual women's interviews. Interviews were completed with 699,686 women, for a response rate of 97 percent.

To get information on schools District Information on Systems in Education (DISE 2005) is used. We use aggregate district-level data available from the DISE website for the year 2005. We also use primary census abstracts for the year 1991 to get information on district-level literacy rates and sex ratios. Finally, information on DPEP status was collated manually using various GOI review reports published by NEUPA to map the progress of DPEP over the years.

The target group of the program consists of women, below the age of 19 in 1994. In 2015, this corresponds to women below the age of 40. Thus, for our

analysis, we focus only on women below the age of 40. This provides us with a sample of 546,022 eligible women. Out of these, 376,871 women are married in the sample (69 percent) and 329,561 women have given birth to at least one child (60 percent). The average age of women in the sample is 26 years. The mean years of education is 7.5. In the sample, almost half of the women marry by the age of 18 (the average age at marriage for women is 18.65 years) and have their first child by the age of 20-21. Table 1 has detailed descriptive statistics for all variables including marriage, fertility, household indicators, and surplus variables (women's health access, domestic violence, etc.). Table 13 has definitions of each variable used in the analysis.

3 Estimation Strategy

The decision of an individual to invest in education is correlated with various unobserved family, social and individual characteristics which might also affect their marriage and fertility outcomes. This makes it difficult to casually estimate the effect of education on marriage market outcomes. The District Primary Education Program (DPEP) provides a quasi-random variation in access to education that can be used to overcome the endogeneity of education. DPEP was targeted to districts with low educational outcomes. Districts with an average female literacy rate below the national average of 39.3 (Census 1991) were eligible to get funding under the program. We first estimate the effect of the program on years of education using the regression discontinuity framework similar to Khanna (2023). The identification of the causal effects of the DPEP program comes from the assumption that all other

factors determining the outcomes are continuous with respect to female literacy (Lee & Lemieux, 2010; Van der Klaauw, 2008).

There is imperfect compliance with DPEP on female literacy rates. It was found that not all districts below the cut-off got the treatment while some districts that were not eligible (i.e above the cut-off) received the treatment. In a setting of imperfect compliance, a fuzzy regression discontinuity design can be applied to estimate treatment effects. We estimate the first stage relationship between the running variable and treatment status in the close neighborhood of the centered female literacy rate using equation 1 below.

$$T_{id} = \alpha + \gamma 1[X_d \leq c] + f(X_d) + \epsilon_{id}, \qquad c - h \leq X_d \leq c + h \tag{1}$$

where X_{id} is the centered assignment variable (39.3 - district female literacy rate). T_{id} is a dummy that takes value 1 if the individual belongs to a district that got DPEP. $1[X_d \leq c]$ is a deterministic and discontinuous function of the female literacy rate that equals 1 if the centered female literacy rate of district d is below 0 (below 39.3 district female literacy rate) and 0 otherwise; $f(X_{id})$ is a function used to flexibly model X_{id} and allowing for different slopes on different sides of the cutoff; h_n is selected using mean square error (MSE-RD) optimal bandwidth (Calonico et al., 2017).

In the second stage we estimate equation 2,

$$Y_{id} = \beta + \tau_{FRD}\hat{T}_{id} + g(X_d) + \varepsilon_{id}, \quad c - h \leq X_d \leq c + h \tag{2}$$

where Y_{id} is either age at marriage of the women or other marriage market

outcomes; $\hat{T}_{id}$ is the estimated probability of treatment from the first stage; τ_{FRD} is the main coefficient of interest which gives us the impact of DPEP on the outcome variable; $g(X_d)$ is a polynomial controlling for smooth functions of female literacy rate in district d and allowing for different slopes on different sides of the cutoff to account for the conditional expectation of the outcome.

The regression discontinuity specification in equation 2 measures the effect of the DPEP program on education and age at marriage. However, our main question is to estimate the effect of education on the age at marriage and not the DPEP program. The DPEP assignment rule can be used as an instrument to identify the causal effect of education. We create an indicator variable that takes value 1 if the district is below the average literacy cut-off and 0 otherwise.

The 2-SLS approach is shown in the equations 3 and 4 below:

$$Educ_{id} = \delta + \theta 1[X_d \leq c] + f(X_d) + \epsilon_{id}, \quad c - h \leq X_d \leq c + h \tag{3}$$

$$Y_{id} = \zeta + \tau_{IV} E\hat{duc}_{id} + g(X_d) + \varepsilon_d, \quad c - h \leq X_d \leq c + h \tag{4}$$

In equation 3, the instrument $1[X_d \leq c]$ captures the discontinuity in the relationship between education $Educ_{id}$, and district female literacy rate $f(X_d)$. Since this discontinuity is the source of exogenous variation in education, the analysis is carried out only for districts in the close neighborhood of the cut-off. In equation 4, $E\hat{duc}_{id}$ is the estimated exogenous change in education. τ_{IV} is the main coefficient of interest which gives us the impact of education on the outcome variable.

3.1 Validity checks

In figure 2, we first show a discontinuity in receiving the treatment on the centered female literacy rate at the cut-off. The districts lying in the close neighborhood around the cut-off show a significant difference in the probability of receiving the treatment. The probability of treatment assignment jumps by nearly 20 percentage points for districts just below the literacy cut-off.

The validity of RD design requires that there is no manipulation of the assignment variable around the cutoff. The DPEP program was introduced for the first time in the year 1994. As the eligibility criteria for DPEP funding was based on a predetermined variable (female literacy rate as per the 1991 census) individuals do not have precise control to select themselves into the program. We further provide a formal test to check whether the density of the assignment variable is continuous or not around the cut-off. In figure 3, we can see that there is no discontinuity in the assignment variable. Further, to the best of our knowledge, no other government program used a female literacy rate for program eligibility.

Finally, we provide a balance test on predetermined variables that would otherwise bias the estimated parameters (table 2). We use the district-level census data 1991 (the program was implemented in 1994) to estimate the difference in the pre-determined variables using the RDD method discussed above. The RDD coefficients are not significantly different from zero.

4 Results

Our main results examine the effect of education on women's age at marriage and other marriage markets and fertility outcomes. Table 3 reports the estimate for an increase in women's education due to the program using parametric and non-parametric inference procedures as shown in equation 2. In the table, we show the impact of the program using sharp RDD, fuzzy RDD, and local linear specifications. We find that the program leads to an increase in women's education of around 0.4 to 1 year. Our estimates are comparable to Sunder (2020) who also find that the program increased women's education by around 0.8 years. Another study by Akresh, Halim, and Kleemans (2023) on the long-term effect of the school construction program in Indonesia, reports an average effect of 0.46 years of education for women in the treated district. One of the reasons for the slightly larger effect in our study could be because we are estimating a local average treatment effect (LATE) for those districts around the cut-off who were induced into taking the program as opposed to the average treatment effect.

The main question of the paper is to estimate the impact on age at marriage due to an increase in education. To show the relation between education and age at marriage, we use the 2SLS approach as shown in section 3. We present the estimates using 2SLS in table 4. In the first stage, we use the female literacy cut-off indicator as an instrument for education around the close neighborhood of the cut-off. We use bandwidth from previous fuzzy RDD specifications where we estimate the impact of the DPEP program on education (section 4). The estimated bandwidth using the MSE-optimal framework is (+-)5.13. It is used in all IV specifications.

Table 4 shows the second stage results of the impact of education on age at mar-

riage using OLS and IV estimation. The OLS estimates show a positive relationship between education and age at marriage. However, this estimate is biased due to the unobservable confounders. The IV estimates show that an increase in education is associated with a fall in the age at marriage for women aged 15-40 by nearly 12.8 months. For the women who have completed their marriage cycle i.e those aged 25-40 in 2015, the fall in the age at marriage is nearly 18 months. For the age cohort, 25-35, the decrease is almost 9 months. The results suggest that on average educated women in the treated districts are married just after reaching the legal age of marriage, 18. Further, we strengthen our results using various robustness checks which are discussed in the section 8.

5 Conceptual framework

In economics literature the marriage market is usually analyzed using either a frictionless matching framework or search models. In the search model frictions are important. It involves search costs and discounting the risk of never finding a partner. Matching models on the other hand assumes a frictionless environment i.e, each woman has access to a pool of all potential men with perfect knowledge of the characteristics of each of them. In India, marriages are predominantly within the same caste community. Chiplunkar and Weaver (2021) report that 94% of the marriages occur within same caste or *jati*. The links within the community are strong. Most marriages occur within the same district.[5] We therefore assume full

[5]In the context of India, marriage migration for women is the norm. Usually, a woman leaves her place of origin to join her husband's family. However, 73% of the women stay within their birth district after marriage (Beauchamp, Calvi, & Fulford, 2017).

information available to the family about the match, especially within a district. This allows us to use a frictionless matching framework for our setting (Chiappori, 2020; Chiappori, Dias, & Meghir, 2018; Low, 2014).

We build an ad-hoc model to understand our empirical findings on the relationship between education and age at marriage. We use a transferable utility (TU) framework in a unitary household model.[6] For women, we have two dimensions: education (H_w) and age (a_w). For men, we have one dimension, income (y). Men prefer to marry younger women due to lesser autonomy, and perceived high quality. Also, the education of women is a desirable attribute in the marriage market due to the inter-generational transmission of human capital. For women's parents, a daughter's education increases the chances of her securing a better match.

Individuals care about children (Q) and private consumption (q). The post-marriage surplus, $s(y, H_w, a_w)$, produced from the consumption can be estimated by maximizing the sum of utilities of men and women. Let the surplus exhibit the following properties:

1. Supermodularity in income and education: $\frac{\partial s^2}{\partial y \partial H_w} > 0$
2. Women's preference for high income: $\frac{\partial s}{\partial y} > 0$
3. Men's preference for educated brides: $\frac{\partial s}{\partial H_w} > 0$
4. Men's preference for younger brides: $\frac{\partial s}{\partial a_w} < 0$

The household surplus is supermodular in income and women's education. Given the preferences, the surplus is increasing in the education of women and

[6]In a unitary household model one maximizes the total surplus of the household and not the share within the household

decreasing in the age of women. This will create a negative association between the two traits in the matching function. To see this trade-off mathematically, we derive the marginal rate of substitution between these two traits along the surplus function. In the appendix, we show the surplus maximization and marginal rate of substitution for a specific functional form.

$$MRS = \frac{\frac{\partial s}{\partial H_w}}{\frac{\partial s}{\partial a_w}} = \frac{\partial a_w}{\partial H_w} < 0$$

This framework implies that given men's preferences for educated and young women in the marriage market, educated women benefit in the marriage market by entering the marriage market at an earlier age. Given low returns in the labor market educated women enter the marriage market to earn a positive benefit from the match or higher surplus post-marriage. To check this implication empirically, we analyze if education leads to a stable match and if there is an improvement in women's post-marriage well-being indicators in the section 6.

There are other possible explanation for the negative association between education and age at marriage. For instance, Buchmann et al. (2021) highlight the role of imperfect information about the quality of bride in the marriage market. Men prefer a particular bride *'type'*. The characteristic of the bride *'type'* is largely explained as someone who is docile and has traditional values. Unfortunately, this information is not easily available before marriage. It is assumed that the quality of bride *'type'* is decreasing in women's age. In this framework even though everyone would benefit from a more educated bride, educated women pool with less educated women to signal their quality, as delaying marriage is expensive. Using an RCT in

Bangladesh, the paper uses this framework to show that increasing education might lead to a fall in age at marriage. They also find that educated women pay a penalty in the marriage market as they are paying higher dowries with no significant changes in groom quality. In our paper, we also find that for educated women there are no significant changes to groom quality (using education as an indicator) although, more educated women are marrying into wealthier families and have better fertility outcomes (see section 6).

Another possible explanation for our results comes from the dowry channel. In India dowry is a transfer of wealth during marriage from brides family to the groom. Dowry is almost a universal phenomenon with recent estimates showing that the payments are around the annual income of the household (Anderson, 2003; Chiplunkar & Weaver, 2021). The relationship between dowry and education can also explain a fall in age at marriage. Due to assortative matching, the dowry amount increases with an increase in the education of the women as women with higher education tend to match with men with higher education/income. Also, given that younger women are preferred in the marriage market, the dowry payment will be an increasing function of the age of women. This means that dowry payment is increasing in both the education and age of women. In order to avoid the higher payment of dowry due to an increase in education the family of educated women would marry the women at a younger age. This provides an alternative explanation for the fall in age at marriage due to an increase in women's education. In the robustness section we provide further results to test this theory.

6 Impact of education on marriage surplus

At equilibrium, a stable match is formed when there is an increase in the individual's utility from the match or if they do not find a better match than the current one. Hence, we check if there is an increase in the surplus within marriage for the educated woman. An increase in education should be followed by an increase in the surplus if the education of women is a preferred attribute in the marriage market. We use a similar IV framework as discussed in the section 3 to identify the impact of women's education on their post-marriage well-being indicators. We focus on some important indicators - the experience of domestic violence and their health and wealth status post-marriage.

6.1 Domestic violence

The stability of marriage is usually measured by divorce rates. In India, since the divorce rates are very low. Hence, it does not provide a good measure of the stability of the match. Instead, we use domestic violence and other post-marriage indicators of conflict or an unstable match. We use two variables to measure the extent of domestic violence. First, *Any Violence*, is the ratio of women who reported in the survey that they faced any form of physical, sexual, or emotional violence or control behavior by the partner. It can be used as a direct measure of the conflict within marriage. We find that the probability of *Any Violence* decreases due to an increase in education. As shown in table 5, *Any Violence* dropped significantly by a little more than half, around 51 percent due to an increase in education but the impact is not significant. The control mean of 0.35 shows the impact of education on *Any*

Violence is substantial. In DHS, a random sub-sample was used for the domestic violence module. The sample size is small, around 9000, for randomly selected data on domestic violence from DHS. This can lead to higher confidence intervals.

Second, *Justifies Violence* records if the woman justifies violence under any circumstance i.e. if the wife thinks that her husband can beat her if she was unfaithful, disrespectful or in any other circumstance. The negative and significant coefficient of -0.16 in this specification suggests that due to education fewer women justify violence within marriage. On average 39 percent of women in the control group justify violence. An increase in education leads to a significant drop of about 58 percent. The reduction both in the experience and justification of domestic violence indicates that with an increase in education, a more stable match is achieved.

6.2 Wealth and Health

We use other measures to test whether more educated women benefit from the match. We check if women marry in a wealthier household or avail of health care benefits post-marriage. In this section, we check the impact of an increase in education on wealth and healthcare access.

First, *Household wealth* is used as an indicator of the husband's wealth percentile category. We create a binary variable indicating if the household is above or below the median on the wealth distribution. Using our IV specification (as in section 3), we find that the educated woman in the treated districts is more likely to get married in wealthy households as compared to uneducated women (see column 1 table 6). This indicates assortative matching on women's education and men's wealth.

Second, healthcare access is measured using hospital delivery, antenatal care,

use of contraception, and fertility. We present these results in columns 2-5 of table 6. We find there is nearly a 10 percent increase in hospital delivery post-marriage due to education. There is an 9 percent increase in antenatal care access for educated women post-marriage. The use of contraception also increases by 23 percent for educated women. Education also causes a decrease in fertility by around 11 percent. These measures indicate improved healthcare access for women post-marriage.

7 Labour market returns and age at marriage

Education for women is valued in the marriage market and labor market. The outside option for the women can play a significant role in the decision of marriage. In the paper, we find that educated women have lower age at marriage as compared to uneducated women. But this may change if educated women have a better outside option. Here, we investigate the impact of an increase in the labor market returns on the age at marriage for educated women.

The labor market returns can be measured by women's wage levels in the district, an intensive margin measure, and female labor force participation at the district level, an extensive margin measure. The wage variable is constructed using National Sample Survey (2005) weekly wage variable for women. Using the same database we create female labor force participation at the district level.

Here, the objective is to understand the impact of education due to an increase in the wage level on the age at marriage. We use a reduced form specification where the DPEP cut-off indicator is used as a proxy for education. To measure the impact we interact the cut-off indicator variable with wage level as shown in the equation

5. We can also use the IV specification but the interaction specification in RDD reduces the significance of the instrument making it invalid for interpretation.

$$Y_{id} = \zeta + \beta_1 1[X_d \leq c] + \beta_2 Wage_d + \tau 1[X_d \leq c] * Wage_d + \varepsilon_d, \quad -h \leq X_d - c \leq h \tag{5}$$

where Y_{id} is the outcome variable, age at marriage, $1[X_d \leq c]$ is the cut-off indicator of the program as an instrument for education, $Wage_d$ is the district-level women's wages, and τ estimates the differential impact of the increase in education depending on the wage level of the district.

In table 7, we find a positive coefficient for the interaction between education and district-level women's wage. It implies there is a delay in age at marriage in the high-wage area as compared to the low-wage area. There is a delay in the age at marriage by 0.5 years as the weekly wage increases by 200 INR ($2.45) for the women i.e. equivalent to 50 percent of the average weekly wage and education increases by one year. The outside option for the women plays an important role in the decision of the marriage. With an increase in the labor market returns, there can be a delay in the age of marriage.

8 Robustness checks

The target group of the DPEP program consists of individuals, below the age of 19 in 1994. In 2015, this corresponds to women below the age of 40. Thus, for our analysis, we focus on women in the 15-40 age group in the year 2015. This provides us with a sample of 546,022 eligible women. Out of these, 376,871 women are

married in the sample (69 percent). In our sample, there can be some individuals who have not yet finished their marriage cycle. For instance, an individual who is 21 years old now could get married at age of 23 but is accounted for as we are only looking at those who are currently married. This leads to censoring bias in the sample. We might underestimate the average age at marriage by censoring individuals who marry later. To deal with this we create another sample where we look at women in the age group 25-40. Since most women in our sample get married by the age of 25, we can say more confidently that the age group 25-40 includes individuals who have completed their marriage cycle[7]. This is shown in column 4 of Table 4. Column 5 of Table 4 compares the impact on age at marriage for age group 25-35. This is the group that was in the school-going age of 6-14 when the program was introduced in their district. Their age at marriage decreases by around 9 months (0.75 years) due to an increase in education. In column 6, we restrict the age group to 15-25. This is the age group that has yet not started their marriage cycle. We find no significance in their age at marriage.

The DPEP program leads to an increase in education for both men and women. This makes it difficult to disentangle the effect of an increase in women's education from an increase in men's education on age at marriage. To understand more clearly the mechanisms for the fall in age at marriage for women we carry out two separate analyses. First, we check the impact of an increase in education on the husband's age at marriage. DHS has information on the husband's characteristics. This sample survey was conducted on randomly drawn men from the full women sample. Using a similar IV specification, we find that there is no impact of education on the

[7]96 percent in the sample get married by the age of 25.

husband's age at marriage as shown in table 8. This implies that due to the increase in education, only women's age at marriage has changed and not men's. Further, we also check the education of husband's in the sample. We find that there is no significant impact on husbands' education. This highlights that the post-marriage effect on surplus is due to an increase in women's education and not due to husbands' education.

An increase in women's education can have a heterogeneous impact on age at marriage depending on the level of education attained. Here, we check for the distributional impact on age at marriage at different quantiles of education attained. We perform IV quantile regression to study the distributional impact of education on age at marriage using the framework of Kaplan and Sun (2017). Table 9 shows the impact of depending the level of women's education.[8] We find that there is a fall in age at marriage for the mean and median level of education (8 years). At higher education quantiles there is a further decrease in age at marriage. Hence, we find the fall in age at marriage is not just around the mean but is also prominent along the distribution. Lastly, we check if there are any differences in the ever-married status of women due to an increase in education. We do not find any such effects for marriages before age of 15. Most of the marriages happen from the age of 17 to 19 in Table 10.

Next, we explore an alternative explanation for the fall in age at marriage. The theoretical framework in section 5 suggests that there is a fall in the age at marriage of women due to education and youth being valuable attributes in the marriage market. However, dowry can also play a role that is not explicit in this setup.

[8]The education quantiles follow the categorisation as mentioned: Q25 has 4 years of education; Q50 has 8 years of education; Q75 has 11 years of education.

The dowry payment is around the annual income of the household (Chiplunkar & Weaver, 2021). The relationship between dowry with education and age can also explain the fall in age at marriage. Due to assortative matching, the dowry amount increases with an increase in the education of the women. As women with higher education will match with men with higher education/income. Also, given that younger women are preferred in the marriage market, the dowry payment will be an increasing function of the age of women. Dowry payment is increasing in both the education and age of women. So the family of educated women will have to pay a higher amount of dowry. But to avoid the higher payment of dowry the family of educated women would marry the women at a younger age. This relationship with dowry could also lead to a fall in age at marriage due to an increase in women's education. This could be an alternative explanation.

We test for the changes in the impact of age at marriage depending on the high vs. low dowry payment. To study this we produce reduce form estimates using the specification as in equation 5:

$$Y_{id} = \zeta + \beta_1 1[X_d \leq c] + \beta_2 Dowry_d + \tau 1[\hat{X_d} \leq c] * Dowry_d + \varepsilon_d, \quad -h \leq X_d - c \leq h \tag{6}$$

where Y_{id} is the outcome variable, age at marriage, $1[X_d \leq c]$ is the cut-off indicator that is the instrument for education, $Dowry_{id}$ is the girl's marriage expense, and τ estimates the differential impact of the increase in education depending on the level of dowry payment. We use marriage expense data from the Indian Human Development Survey (2011). We refer to the girl's family expense as a dowry

payment in this estimation.

Table 12 shows the estimates for interaction specification with the dowry payment. We find that there is no significant impact when studying the interaction with the dowry payment. The negative interaction coefficient (not significant though) does not support the alternative explanation of a fall in age at marriage due to the girl's family preferring a lower dowry payment.

9 Conclusion

Over the past few decades, India has witnessed significant progress in access to education for girls. However, recent evidence shows that in many countries an increase in education has not translated into improved labor market outcomes for women (Carvalho & Evans, 2022). In the context of low labor market returns to women, this study tries to understand how an increase in women's education affects their marriage market outcomes. Specifically, how increases in education affect the timing of marriage. We estimate this relationship by exploiting a quasi-random variation created by a large-scale education intervention in India called DPEP (1994) that targeted districts with low female literacy rates.

Our empirical findings show that a one-year increase in women's education leads to a decrease in her age at marriage by 0.75-1.55 years. We explain these findings using an ad-hoc matching model framework. We show that in a two-sided market men's preference for young and educated brides drives the negative relationship between the education of the woman and her age at marriage. Further, we check the stability of the match and increase in marriage surplus. We find the increase in

women's education leads to a fall in domestic violence, better healthcare access for maternal care, marriage market match in wealthy households, and a fall in fertility level. Finally, we find that the effect of education on age at marriage varies by the availability of an outside option in the labor market. A 200 rupee increase in women's wages (50 percent of weekly income) leads to a delay in the age at marriage for educated women by 0.5 years.

Our findings have important implications for policy. In countries where women traditionally have early marriages and are less likely to work outside the home, increasing education might not be enough to achieve the policy goal of delaying marriage. We highlight the importance of complementarity of policies to delay age at marriage. Education as a policy tool needs to be combined with other policies that provide better economic opportunities to women to delay their age at marriage. One of the limitations of this research is the inability to isolate the direct human capital effect of an increase in women's education on post-marriage well-being as educated women marry up (into wealthier households). Further research is needed to understand the mechanisms for the improvement in well-being indicators for more educated women.

10 FIGURES

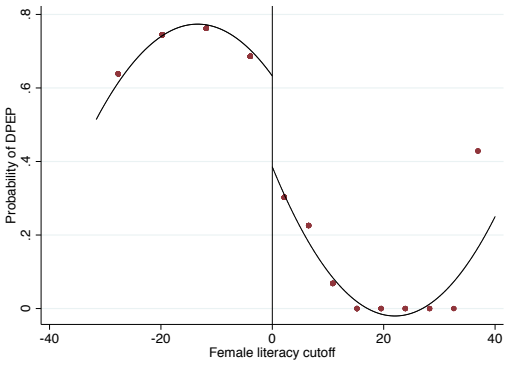

Figure 2 Probability of receiving DPEP
Figure Notes: This figure plots the discontinuity in the probability of receiving DPEP for districts around the female literacy cutoff. The districts to the left of zero receive the program and the districts to the right do not.

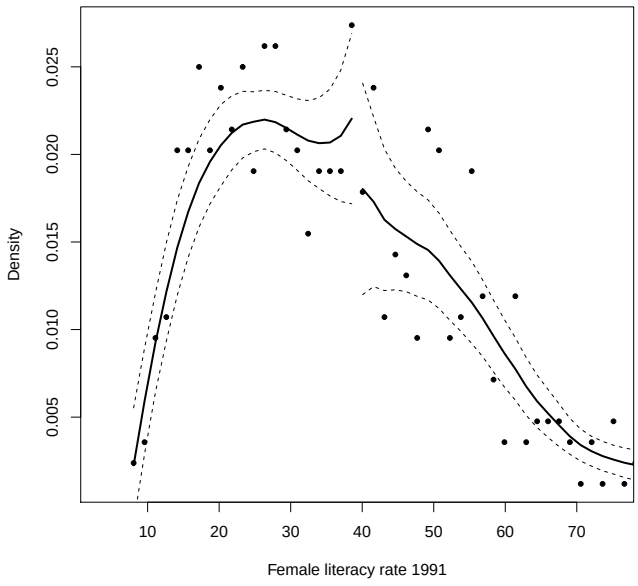

Figure 3 Mccrary Test
Figure Notes: This figure plots the continuous density of the assignment variable around the cutoff.

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11 TABLES

Table 1 Descriptive statistics

	N	Mean	SD	Min	Max
DHS, 2015-16					
Marriage and fertility					
Age at marriage	360366	18.65	3.72	10	40
Ever Marry	546022	0.69	0.46	0	1
Marry before 18	360366	0.40	0.49	0	1
Marry before 15	360366	0.11	0.31	0	1
Ever gave birth	546022	0.60	0.49	0	1
Total children	546022	1.46	1.56	0	15
Background variables					
Woman age	546022	26.03	7.14	15	40
Education	546022	7.49	5.01	0	20
Partner age at marriage	62902	23.38	4.75	10	40
Partner Age	63371	33.77	7.28	15	70
Partner Education	65585	8.00	4.86	0	20
Post- marriage surplus variables					
HH. Wealth Index	546022	5690.85	97468.43	-240323	300055
Faced any violence	48901	0.32	0.47	0	1
Justifies violence	93747	0.39	0.49	0	1
Hospital deliveries	182107	0.78	0.41	0	1
Antenatal care received	180666	0.83	0.38	0	1
Use contraception	383566	0.56	0.50	0	1
IHDS 2014-15, Marriage expenses					
Marriage expense median (girl)	305299	198599.6	112151.2	10000	1250000
Marriage expense median (boy)	305299	128926.1	69395.71	12500	750000
Diff. Marriage expense median (girl-boy)	305299	59950.52	55074.51	-20000	500000
NSSO 2005, Wages					
Median District wage (Men)	496473	571.12	381.89	175	2215
Median District wage (Women)	491422	414.12	444.66	90	3000
Census, 1991					
DPEP	546022	0.40	0.49	0	1
Female lit. rate 1991 (centered)	470686	-3.11	17.09	-31.6	54.7
States	36				
Districts	629				
Observations	546,022				

Notes: Summary statistics for different data-sets combined. DHS (2015-16): Sample from woman questionnaire for all those who were young in 1994-2005, IHDS 2014-15, NSSO (2005), Employment Unemployment Survey and Census of India (1991): District level Primary census abstracts. The combined data consists of total 546,022 observations from 629 districts (including splits) out of which 265 got DPEP and remaining did not.

Table 2 Balance test covariates (Female)

	(1) Sex ratio	(2) %Primary25-44	(3) %Married 15-24	(4) %Married 25-44	(5) %Main work
Robust	-36.705	0.023	0.071	0.025	-0.102
	[59.443]	[0.024]	[0.117]	[0.047]	[0.172]
Sample Mean	928.29	0.10	0.58	0.93	0.29
BW districts	161	207	220	200	312
Bandwidth	10	12	12	12	19
VCE method	NN	NN	NN	NN	NN
BW type	mserd	mserd	mserd	mserd	mserd

Notes: Data are taken from Census (1991). The balance test checks the difference between DPEP and non-DPEP districts before the program was implemented. We use fuzzy RDD design to estimate the impact on the predetermined variables (Calonico et al., 2017). The bandwidth selection is done using data-driven mean square error (MSE-RD) optimal bandwidth methodology. The estimation is done at the district level. We use the nearest neighbor (NN) cluster robust standard errors at the district-age level.

Table 3 Impact of District Primary Education Program (DPEP) on women's education

	(1) Sharp RDD	(2) Fuzzy RDD	(3) Linear	(4) Poly
DPEP	0.32	0.99	0.18	0.25
	[0.15]	[0.58]	[0.09]	[0.11]
Sample Mean	8.11	7.99	8.02	8.02
Obs.	470686	470686	106804	106804
BW-left	7.77	5.13	5.13	5.13
BW-right	7.77	5.13	5.13	5.13
BW type	mserd	mserd		

Notes: Data are taken from DHS (2015-16). Here we estimate the impact of the DPEP program on women's education. All the columns have women's education as the dependent variable. We present RDD estimates using non-parametric and parametric local linear regression estimation with optimal bandwidth selection MSE. We use cluster robust standard errors at the district age level. Column 1 shows sharp RDD estimates, column 2 shows fuzzy RDD estimates, columns 3-4 estimates for local linear regression with column 4 including quadratic polynomial.

Table 4 Impact of education on age at marriage: IV results

	OLS		IV			
	15-40	25-40	15-40	25-40	25-35	15-25
Educ.	0.30	0.32	-1.07	-1.55	-0.75	0.06
	[0.01]	[0.01]	[0.41]	[0.75]	[0.32]	[0.20]
Obs.	56885	42400	65940	49165	38172	21096
Control Mean	18.76	19.14	18.76	19.14	18.99	19.03
CD Fstat			13.85	7.10	15.59	8.60

Notes: Data are taken from DHS (2015-16). For all columns, the dependent variable is the age at marriage. In columns 1 and 2 we present the OLS results for the entire cohort of 15-40 and the restricted cohort of 25-40 respectively. In column 3 we present the IV results with a mean square error (MSE-RD) bandwidth of 5.13 for the entire cohort aged 15-40. Column 4 shows results for the sample in the age group 25-40 with an MSE-RD bandwidth of 5.13. In columns 5 and 6, we present the IV results for the cohort aged 25-35 and 15-25 respectively, both with MSE-RD bandwidth of 5.13. The bandwidth of 5.13 is estimated using MSE optimal selection while estimating the impact of the DPEP program on women's education from table 3 (Calonico et al., 2017). The cut-off indicator takes value 1 if the woman belongs to the district which was eligible in the DPEP program i.e. female literacy below 39.3 else zero.

Table 5 Impact of education on domestic violence

	Any Violence	Justifies Violence
Educ.	-0.53	-0.16
	[0.51]	[0.05]
Observations	8759	16375
Control Mean	0.35	0.39
CD Fstat	1.04	12.62

Notes: Data are taken from DHS (2015-16). All the specifications use IV-RDD specification with the cut-off indicator as an instrument for women's education. This table shows the IV estimates for the impact of education on domestic violence variables. The first column records if the woman has experienced any sort of physical, sexual violence or has faced control issues. The second column records if the woman justifies violence if the wife was unfaithful or disrespectful. The cut-off indicator takes value 1 if the woman belongs to the district which was eligible in the DPEP program i.e. female literacy below 39.3 else zero.

Table 6 Impact of education on wealth and healthcare access

	(1) Hsld. Wealth	(2) Hospital Delivery	(3) Antenatal care	(4) Contraception	(5) Fertility
Education	0.16	0.09	0.08	0.14	-0.16
	[0.02]	[0.02]	[0.02]	[0.05]	[0.04]
Observations	99422	31722	31378	69939	99422
Control Mean	0.40	0.83	0.88	0.60	1.42
CD Fstat	40.90	25.40	25.61	13.02	40.90

Notes: Data are taken from DHS (2015-16). All the specifications use IV-RDD specification with the cut-off indicator as an instrument for women's education. The table shows the IV estimates for the impact of education on wealth and health-related variables. The reference for column 1 is individuals belonging to the DHS wealth categories - middle, poorer and poorest. The reference for columns 2 - 4 is no access to that particular healthcare facility. The cut-off indicator takes value 1 if the woman belongs to the district which was eligible in the DPEP program i.e. female literacy below 39.3 else zero.

Table 7 Interaction education and wage levels (reduced form): age at marriage

	(1) Age at marriage
Education	-0.3107
	[0.12]
Education*Wage	0.0005
	[0.00]
Observations	64839
Control Mean	18.87

Notes: Data are taken from DHS (2015-16) and NSSO (2010-11). The cut-off indicator is used as a proxy for women's education that is further interacted with district-level wages for women in the reduced form specification in the equation 5. We report reduced form results because the IV is weak in the interaction specification with a very low CD Fstat. The standard error for the interaction coefficient is 0.00016.

Table 8 Impact of education on husband's characteristics

	(1) Husband's AM	(2) Husband's Education
Men's Education	-0.30	–
	[2.11]	
Women's Education	–	-0.02
		[0.09]
Obs.	11082	11623
Control Mean	24.06	1.73
CD Fstat	0.26	5.16

Notes: Data are taken from DHS (2015-16). All the specifications use IV-RDD specification with a cut-off indicator as an instrument. In column 1, the dependent variable is the husband's age at marriage with the cut-off indicator as an instrument for men's education. In column 2, the dependent variable is the husband's education and the cut-off indicator is used as an instrument for women's education.

Table 9 Impact of education on age at marriage: IV-Quantile

	(1) Q1	(2) Q2	(3) Q3	(4) Q4
Education	0.25	-0.13	-0.31	-0.50
	[0.01]	[0.07]	[0.11]	[0.16]
Observations	311670	311670	311670	311670

Notes: Here we estimate the quantile regression model using methodology by Kaplan and Sun (2017). It estimates the causal effects at levels or quantiles of women's education. We have four quantiles of education at 0.25 (Q1), 0.5 (Q2), 0.75 (Q3), and 0.9 (Q4). The level of education for Q1 is 4 years, Q2 is 8 years, Q3 is 11 years and Q4 is 14 years. The table highlights the heteregeneity depending on the level of education.

Table 10 Impact of education on marriage decision

	Ever Marry	Marry before 18	Marry before 15
Educ.	-0.02	0.09	0.04
	[0.01]	[0.04]	[0.02]
Obs.	99422	65940	65940
Control Mean	0.71	0.38	0.10
CD Fstat	40.90	13.85	13.85

Notes: Data are taken from DHS (2015-16). All the specifications use IV-RDD specification with the cut-off indicator as an instrument for women's education. The dependent variable in column 1 is the indicator variable which takes value 1 if the woman has ever married else zero, column 2 has an indicator which takes value 1 if women marry before the age of 18 else zero, and column 3 has an indicator which takes value 1 if women marry before the age of 15 else zero.

Table 11 Impact of education on marriage expenses: IV results

	Girl Exp	Boy Exp	Diff:girl-boy
Educ.	0.07	-0.30	0.93
	[0.09]	[0.10]	[0.22]
Obs.	8184	8182	6696
Control Mean	12.08	11.63	11.13
CD Fstat	66.93	67.11	33.28

Notes: Data are taken from the IHDS (2011). Here we estimate the relationship between the increase in women's education and marriage expenses. Column 1 has the girl's marriage expense, Column 2 has the men's marriage expenses and column 3 has the difference in the payment (bride-groom or girl-men). IV results are shown in the table. The cut-off indicator is used as an instrument for women's education.

Table 12 Interaction of education and dowry (reduced form): age at marriage

	Age at Marriage
Educ.	0.98
	[2.00]
Educ*Marr.exp	-0.10
	[0.17]
Obs.	3336
Control Mean	17.85

Notes: The marriage expense data is from IHDS (2011). The cut-off indicator is used as a proxy for women's education that is further interacted with marriage expenses in the reduced form specification in the equation 6. Marriage expense refers to the girl's family's marriage expense. We report reduced form results because the IV is weak in the interaction specification with a very low CD Fstat.

References

Adams, A., & Andrew, A. (2019). *Preferences and beliefs in the marriage market for young brides* (tech. rep.). IFS Working Papers.

Adukia, A., Asher, S., & Novosad, P. (2020). Educational investment responses to economic opportunity: Evidence from indian road construction. *American Economic Journal: Applied Economics*, *12*(1), 348–76.

Akresh, R., Halim, D., & Kleemans, M. (2023). Long-term and intergenerational effects of education: Evidence from school construction in indonesia. *The Economic Journal*, *133*(650), 582–612.

Anderson, S. (2003). Why dowry payments declined with modernization in europe but are rising in india. *Journal of Political Economy*, *111*(2), 269–310.

Anderson, S., & Bidner, C. (2015). Property rights over marital transfers. *The Quarterly Journal of Economics*, *130*(3), 1421–1484.

Anukriti, S., & Dasgupta, S. (2017). Marriage markets in developing countries. *The Oxford Handbook of Women and the Economy*, 97–120.

Anukriti, S., Kwon, S., & Prakash, N. (2020). Saving for dowry.

Ashraf, N., Bau, N., Nunn, N., & Voena, A. (2020). Bride price and female education. *Journal of Political Economy*, *128*(2), 591–641.

Attanasio, O. P., & Kaufmann, K. M. (2017). Education choices and returns on the labor and marriage markets: Evidence from data on subjective expectations. *Journal of Economic Behavior & Organization*, *140*, 35–55.

Azam, M., & Saing, C. H. (2017). Assessing the impact of district primary education program in india. *Review of Development Economics*, *21*(4), 1113–1131.

Banerjee, A., Duflo, E., Ghatak, M., & Lafortune, J. (2013). Marry for what? caste and mate selection in modern india. *American Economic Journal: Microeconomics*, *5*(2), 33–72.

Beauchamp, A., Calvi, R., & Fulford, S. (2017). Terms of engagement: Marriage and migration in india. *PAA 2017 Annual Meeting*.

Becker, G. S. (1973). A theory of marriage: Part i. *Journal of Political Economy*, *81*(4), 813–846.

Behrman, J. R., Foster, A. D., Rosenweig, M. R., & Vashishtha, P. (1999). Women's schooling, home teaching, and economic growth. *Journal of Political Economy*, *107*(4), 682–714.

Biswas, S., & Das, U. (2021). Whats the worth of a promise? evaluating the indirect effects of a program to reduce early marriage in india. *arXiv preprint arXiv:2104.12215*.

Borkotoky, K., & Gupta, A. K. (2016). Trends and patterns of educational homogamy in india: A marriage cohort analysis. *International Journal of Population Research*, *2016*.

Breierova, L., & Duflo, E. (2004). *The impact of education on fertility and child mortality: Do fathers really matter less than mothers?* (Tech. rep.). National Bureau of Economic Research.

Brien, M. J., & Lillard, L. A. (1994). Education, marriage, and first conception in malaysia. *Journal of Human Resources*, 1167–1204.

Buchmann, N., Field, E. M., Glennerster, R., Nazneen, S., & Wang, X. Y. (2021). *A signal to end child marriage: Theory and experimental evidence from bangladesh* (tech. rep.). National Bureau of Economic Research.

Calonico, S., Cattaneo, M. D., Farrell, M. H., & Titiunik, R. (2017). Rdrobust: Software for regression-discontinuity designs. *The Stata Journal*, *17*(2), 372–404.

Carmichael, S. (2011). Marriage and power: Age at first marriage and spousal age gap in lesser developed countries. *The History of the Family*, *16*(4), 416–436.

Carvalho, S., & Evans, D. K. (2022). *Girls' education and women's equality: How to get more out of the world's most promising investment*. Center for Global Development.

Chari, A., Heath, R., Maertens, A., & Fatima, F. (2017). The causal effect of maternal age at marriage on child wellbeing: Evidence from india. *Journal of Development Economics*, *127*, 42–55.

Chiappori, P. (2020). The theory and empirics of the marriage market. *Annual Review of Economics*, *12*, 547–578.

Chiappori, P., Dias, M. C., & Meghir, C. (2018). The marriage market, labor supply, and education choice. *Journal of Political Economy*, *126*(S1), S26–S72.

Chiappori, P., Iyigun, M., & Weiss, Y. (2009). Investment in schooling and the marriage market. *American Economic Review*, *99*(5), 1689–1713.

Chiplunkar, G., & Weaver, J. (2021). Marriage markets and the rise of dowry in india. *Available at SSRN 3590730*.

Corno, L., Hildebrandt, N., & Voena, A. (2020). Age of marriage, weather shocks, and the direction of marriage payments. *Econometrica*, *88*(3), 879–915.

Dhar, D. (2021). *Indian matchmaking: Are working women penalized in the marriage market in india?* (Tech. rep.).

DHS. (2017). India national family health survey nfhs-4 2015-16.

Duflo, E. (2001). Schooling and labor market consequences of school construction in indonesia: Evidence from an unusual policy experiment. *American Economic Review*, *91*(4), 795–813.

Field, E., & Ambrus, A. (2008). Early marriage, age of menarche, and female schooling attainment in bangladesh. *Journal of Political Economy*, *116*(5), 881–930.

Fletcher, E., Pande, R., & Moore, C. M. T. (2017). Women and work in india: Descriptive evidence and a review of potential policies.

Goldin, C., & Katz, L. F. (2002). The power of the pill: Oral contraceptives and women's career and marriage decisions. *Journal of political Economy*, *110*(4), 730–770.

Grépin, K. A., & Bharadwaj, P. (2015). Maternal education and child mortality in zimbabwe. *Journal of Health Economics*, *44*, 97–117.

Gyimah, S. O. (2009). Cohort differences in women's educational attainment and the transition to first marriage in ghana. *Population Research and Policy Review*, *28*(4), 455–471.

Heath, R., & Mobarak, A. M. (2015). Manufacturing growth and the lives of bangladeshi women. *Journal of Development Economics*, *115*, 1–15.

Ikamari, L. D. (2005). The effect of education on the timing of marriage in kenya. *Demographic research*, *12*, 1–28.

Jacob, S., & Chattopadhyay, S. (2016). Marriage dissolution in india. *Economic & Political Weekly*, *51*(33), 25–27.

Jalan, J., & Glinskaya, E. (2002). Small bang for big bucks? an evaluation of a primary school intervention in india. *with Elena Glinskaya), mimeo, the World Bank*.

Jayachandran, S. (2017). Fertility decline and missing women. *American Economic Journal: Applied Economics*, *9*(1), 118–39.

Jayachandran, S. (2021). Social norms as a barrier to women's employment in developing countries. *IMF Economic Review*, *69*(3), 576–595.

Jensen, R. (2012). Do labor market opportunities affect young women's work and family decisions? experimental evidence from india. *The Quarterly Journal of Economics*, *127*(2), 753–792.

Jensen, R., & Thornton, R. (2003). Early female marriage in the developing world. *Gender & Development*, *11*(2), 9–19.

Kaplan, D. M., & Sun, Y. (2017). Smoothed estimating equations for instrumental variables quantile regression. *Econometric Theory*, *33*(1), 105–157.

Keskar, A. (2021). Matching on height in india.

Khanna, G. (2023). Large-scale education reform in general equilibrium: Regression discontinuity evidence from india. *Journal of Political Economy*, *131*(2), 000–000.

Kırdar, M. G., Dayıoğlu, M., & Koç, İ. (2018). The effects of compulsory-schooling laws on teenage marriage and births in turkey. *Journal of Human Capital*, *12*(4), 640–668.

Klasen, S., & Pieters, J. (2015). What explains the stagnation of female labor force participation in urban india? *The World Bank Economic Review*, *29*(3), 449–478.

Lavy, V., & Zablotsky, A. (2011). *Mother's schooling and fertility under low female labor force participation: Evidence from a natural experiment* (tech. rep.). National Bureau of Economic Research.

Lee, D. S., & Lemieux, T. (2010). Regression discontinuity designs in economics. *Journal of Economic Literature*, *48*(2), 281–355.

Lefgren, L., & McIntyre, F. (2006). The relationship between women's education and marriage outcomes. *Journal of labor Economics*, *24*(4), 787–830.

Low, C. (2014). Pricing the biological clock: Reproductive capital on the us marriage market. *Manuscript, Wharton School of Business*.

MHRD, N. D., Government of India. (2002). DPEP - 16th Joint Review Mission (November - December, 2002) Progress Overview Report Part 1 [[Online; accessed 10-June-2021]].

Pandey, R. S. (2000). Going to scale with education reform: India's district primary education program, 1995–99. *Education Reform and Management Publication Series*, *1*(4).

Rosenzweig, M. R., & Wolpin, K. I. (1994). Are there increasing returns to the intergenerational production of human capital? maternal schooling and child intellectual achievement. *Journal of Human Resources*, 670–693.

Sipahimalani-Eao, V., & Clarke, P. (2003). A review of educational progress and reform in the district primary education program (phases i and ii).

Smits, J., & Park, H. (2009). Five decades of educational assortative mating in 10 east asian societies. *Social Forces*, *88*(1), 227–255.

Sunder, N. (2020). Parents' schooling and intergenerational human capital: Evidence from india. *Unpublished Manuscript*, *24*.

Van der Klaauw, W. (2008). Regression–discontinuity analysis: A survey of recent developments in economics. *Labour*, *22*(2), 219–245.

A Description of variables

Table 13 Description of variables

DHS, 2015-16	
Marriage and fertility	
Age at marriage	Age at start of first marriage or union.
Every Marry	Dummy for woman who ever got married.
Marry before 18	Dummy for woman who marry before the age 18.
Marry before 15	Dummy for woman who marry before the age 15.
Ever gave birth	Dummy for woman who ever gave birth.
Total children	Total number of children ever born.
Background variables	
Woman age	The present age of the woman.
Education	Education in single years.
Partner Age at marriage	The age at marriage of the current husband.
Partner Age	Age of the respondent's husband or partner.
Partner Education	The current husband/partner's education in single years.
Post-marriage surplus variables	
HH. Wealth Index	Wealth category post marriage
Faced any violence	If the woman faced physical, sexual, emotional violence or control behaviour by partner.
Justifies violence	If the woman justifies physical, sexual, emotional violence or control behaviour under any circumstances.
Hospital deliveries	Delivery in a health institution
Antenatal care received	Access to antenatal care during pregnancy
Use contraception	Access to any type of contraceptive methods
IHDS 2014-15, Marriage expenses	
Marriage expense median (girl)	The median of average marriage expenses for girls reported by the family
Marriage expense median (boy)	The median of average marriage expenses for boys reported by the family
Diff. Marriage expense median (girl-boy)	The difference in median marriage expenses of boys and girls
NSSO 2005, Wages	
Median District wage (Men)	The median of men's weekly wages at the district level.
Median District wage (Women)	The median of women's weekly wages at the district level.
Census, 1991	
DPEP	Dummy for whether the district got DPEP funding or not.
Female lit. rate 1991 (centered)	District level average female literacy minus the national average female literacy rate (39.3).

Notes: This table provides the description of the key variables from the four datasets used in this study.

B Conceptual framework: household problem

The utility for men and women is represented by subscript m and w respectively. Individuals value the private consumption, q, and children and household management as a public good, Q. The household production function follows Cobb-Douglas utility (qQ). The men's family has a preference for young brides. We add cost in the utility function which increases with age of the woman at marriage. $c(a_w)$ is an increasing function of age. Below is the utility for men and women both:

$$u_m = q_m Q - c(a_w)$$

$$u_w = q_w Q$$

We assume the investment in children depends on the parental human capital. The public good, Q, domestically produced from parental human capital is given by Cobb-Douglas utility function.

$$Q = H_m^{\alpha/2} H_w^{\alpha/2}$$

The budget constraint of the household will account for private consumption q and public good consumption i.e. child care. The sum of the consumptions will be equal to household income. We have husband's income, y, bride's income, z, and dowry payment, d. Dowry payment is one time usually around annual income of the husband. But we can consider it as small monthly payment over the life-cycle. Below is the budget constraint for the household. Here we assume the share of private consumption and public consumption

is defined by β.

$$q_m + q_w + \beta Q = y + d + z$$

Dowry is an important part of Indian marriage market. It can exceed annual household income (Chiplunkar & Weaver, 2021). We introduce dowry in the model through budget constraint as an perpetuity monthly payment. For simplification, we assume dowry to be a constant amount.

In India, female labour force participation has stagnated around 30 percent and it has decreased in recent years. So the main investment is in the marriage market (Fletcher, Pande, & Moore, 2017). Labour market returns are low for woman but they do increase with education. We assume similar logarithmic functional form for women's income. The labour market returns can be assumed to be low which means a low value of δ or z'_{H_w}.

$$z = \delta ln(H_w)$$

Here, we maximise the total household utility under the budget constraint. More specifically, we maximise the sum of utilities for men and women in the household, $u = u_m + u_w$. Below is the maximisation problem:

$$\max_{q,Q}. \ (q_m + q_w)(Q) - c(a_w)$$

$$s.t. \ q_m + q_w + \beta Q = y + d + z$$

We get equilibrium private consumptions and public good consumption. The equilib-

rium values for private and public good consumption are:

$$Q^* = \frac{(y + z + d + R)}{\beta + 1}$$
$$q^* = \frac{(y + z + d - R)}{\beta + 1}$$

where $R = \frac{2\delta}{\alpha}$.

B.1 Surplus function

From the optimal values we can get the joint utility for the household. Joint utility of the household, T, is the sum of utilities of men and woman as shown below:

$$T = q^* Q^* - c(a_w)$$
$$T = \frac{1}{(\beta + 1)^2}((y + z + d)^2 - R^2) - c(a_w)$$

Using joint utility we can define the surplus of the household. Surplus function is defined as joint utility minus the utility when the individuals are single. When they are single consume their own income. Using optimal values for private and public good consumption we get surplus function:

$$S(y, z, H_w, a_w) = \frac{1}{(\beta + 1)^2}((y + z + d)^2 - R^2) - c(a_w) - y - z$$

The surplus function depends on labour market income for men and women. It reduces with age of woman at marriage. As men's family prefer younger brides surplus decreasing in the age of woman. We also have surplus increasing in men's income.

B.2 Marginal rate of substitution

Using the surplus function, we estimate the rate of change of surplus with respect to age at marriage and education of the woman. Further, we comment on the marginal rate of substitution between age of marriage and education of the woman.

$$\frac{\partial S}{\partial H_w} = (\frac{2(y+z+d)}{(\beta+1)^2} - 1)z'_{H_w}$$

Given that we have the numerator positive we have surplus increasing in education of women. For that we need $2(y+z+d) > (\beta+1)^2$.

$$\frac{\partial S}{\partial H_w} > 0$$

Next, we estimate the rate of change of surplus with respect to age of marriage. Surplus of the household decreases as the age of woman increases.

$$\frac{\partial S}{\partial a_w} = -c'(a_w)$$

Further, we estimate the marginal rate of substitution ($MRS_{a_{H_w}}$) between age of marriage and education of woman. We estimate the MRS by taking a ratio between marginal surplus of education of woman and age of woman at marriage. If the labour market returns are low for woman then we get the MRS to be negative. The model predicts a negative association between education of woman and the age of marriage. There is demand for young and educated brides. Educated woman are able to find a match earlier after entering the marriage market.

$$MRS = \frac{\partial a_w}{\partial H_w} < 0$$

B.3 Household problem: quasi-linear utility

Here, we use similar set-up as the earlier problem. We use quasi-linear utility functional form where the private consumption does not depend on change in household income. We assume following functional forms:

$$u_m = q_m + ln(Q) - c(a_w)$$
$$u_w = q_w + ln(Q)$$

Another deviation from the above model is we assume dowry increases with education of women. There is evidence of positive correlation between dowry and education of woman (Anukriti, Kwon, & Prakash, 2020). We assume dowry is an increasing function of education of woman. We take a specific logarithmic functional form in our specification. Dowry, d, depends on the woman's human capital, H_w, as shown below:

$$d = \gamma ln(H_w)$$

Keeping rest of the assumption similar to above household problem, we maximise the sum of utilities under the budget constraint. We get following equilibrium values:

$$Q^* = 2\frac{\alpha + \delta}{\alpha\beta}$$
$$q^* = (y + z + d) - 2\frac{\alpha + \delta}{\alpha\beta}$$

This provides us with the following surplus function which is independent of the income (y and z).

$$S(H_w, a_w) = \gamma ln(H_w) - 2\frac{\alpha + \delta}{\alpha\beta} + ln(2\frac{\alpha + \delta}{\alpha\beta}) - c(a_w)$$

The marginal rate of substitution between education of women and age of marriage has a negative relationship using this functional form as well.

$$\frac{\partial S}{\partial H_w} = \frac{\gamma}{H_w}$$
$$\frac{\partial S}{\partial a_w} = -c'(a_w)$$
$$MRS = -\frac{\gamma}{H_w c'(a_w)}$$