Marrying Young: Surprising Effect of Education

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Job market paper

Abstract

In a traditional marriage market, family's preferences and beliefs over bride types play a significant role in matching. In this paper, we study how an exogenous increase in female education, a preferred attribute in the marriage market, affects her age at marriage. The District Primary Education Program (DPEP) launched in 1994, provides a regression discontinuity set-up to estimate the causal impact of education. We find that the program lead to an increase in the women's education by 1.5 years. Next, to see the impact of education on age at marriage, we use the program cut-off as an instrument for education. In contrast to the literature, we find a decrease in the age at marriage by 0.44 years due to increase in education. Using a simple transferable utility model, we provide a framework for a negative relationship between education and the age at marriage. As educated and young brides are more desirable in the marriage market, educated women are cleared from the marriage market before less educated women. Further, we find that an increase in education leads to a stable match. Finally, we check if the effect of education on age at marriage varies by the availability of an outside option in the labor market. Our results indicate that educated women in high wage districts on an average marry later than the low wage districts.

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

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We thank Giacomo De Giorgi and Ana Balcão Reis for useful comments and suggestions.

1 Introduction

Early marriage is still a common practice in many developing countries. In 2015, nearly 27% of Indian women aged 20-24 were married before the legal age of 18 (DHS, 2017). Younger brides are more likely to have poorer health and educational outcomes, lesser autonomy, higher fertility and weaker children (Chari et al., 2017; Corno et al., 2020; Field and Ambrus, 2008; Jensen and Thornton, 2003). Female education can potentially increase women's age at marriage because of increased labour market prospects (Attanasio and Kaufmann, 2017; Chiappori, Iyigun, et al., 2009; Heath and Mobarak, 2015; Jensen, 2012). However, the positive association between education and age at marriage is not obvious due to (a) low perceived labor market returns to women's education (Lavy and Zablotsky, 2011), or (b) preferences and beliefs in the marriage market about brides and grooms (Buchmann et al., 2021). Hence, more evidence is required to understand the relationship between female education and age at marriage.

In this paper, we estimate the impact of primary school expansion on women's age at marriage. In the context of India, marriage decisions are taken by parents especially for the women. Preferences and beliefs play a significant role in finding a match in the marriage market. Men's preference to marry younger women due to longer fertility cycle, lesser autonomy and perceived high quality, is well documented in the literature (Anukriti and Dasgupta, 2017; Caldwell et al., 1983). Also, education of women is a desirable attribute in the marriage market due to the inter-generational transmission of health and education (Chen and Li, 2009; Rosenzweig and Wolpin, 1994; Thomas et al., 1991). For women's parents, daughter's education increases the chances of her securing a better match. According to Adams and Andrew (2019), parents believe that the chance of poorly educated daughter receiving a marriage offer from high quality groom with a government job is very low. In such a setting, we investigate how an exogenous increase in education, a preferred attribute for women in the marriage market, affects her age at marriage.

To causally estimate the relationship between women's education and their timing of marriage, we exploit the quasi-random variation in schooling induced by a large-scale education program in India, District Primary Education Program (DPEP). The aim of the policy was to increase access to primary schooling and reduce the gender gaps in education. DPEP targeted low literacy districts by building schools, hiring teachers and upgrading infrastructure (Jalan and Glinskaya, 2002). Districts where the average female literacy rate was below the national average of 39.3 (Census 1991) were eligible for program benefits. We exploit this discontinuity around the cut-off using regression discontinuity framework similar to Khanna (2015).

Our estimates show that the program leads to an increase in women's education by 1.5 years in the DPEP districts. To put this in context, Duflo (2012), observes an increase of 0.19 years of education due to the school construction program in Indonesia. However, Akresh et al. (2018) show that the long term impact of the same school construction program lead to increase in the education by 0.5 years for women. Azam and Saing (2017), find an increase in 0.27 years of schooling due to DPEP in 2007/08. There could be two reasons for the large effects we find. First, we measure the long term effect of the policy i.e, when individuals have completed their education cycle, and second, we are estimating a local average treatment effect (LATE). Further, on an average DPEP causes a decrease in the women's age at marriage by 0.83 years. However, the RDD estimates do not tell us if the decrease in age at marriage is due to change in education of women in these districts. To check this channel, we use the DPEP assignment rule as an instrument for education to estimate the impact of an increase in education on the age at marriage of women. We find that the age at marriage decreases by 0.44 years for educated women in the DPEP districts. This is contrary to the existing evidence that finds a positive association between education and age at marriage (Breierova and Duflo, 2004; Brien and Lillard, 1994; Ikamari, 2005; Kirdar et al., 2009).

To explain the empirical findings, we use a transferable utility framework in a unitary household model (Chiappori, 2020; Low, 2014). Under transferable utility framework a stable match can be established by maximising the sum of utilities of the partners. In our framework, men are characterised by income and woman are characterised by education and age. We assume men's utility to be decreasing in the age of the women due to their preference for a younger bride. Men value the quality of their children which is increasing in their wife's human capital. In such a context, a stable match at equilibrium implies a negative association between women's education and age at marriage. Given that educated and young brides are more desirable on the marriage market, women who have more education improve their returns on the marriage market as they are cleared from the market before less educated women.

The utility framework shows that utility received by the spouses should be jointly higher than the surplus and that all the individuals receive positive benefit from marriage. A stable match would therefore require an increase in the surplus for women. To check empirically if education leads to an increase in women's surplus in the marriage, we use DPEP as an instrument for women's education around cut-off. We then analyse if education leads to an improvement in women's post marriage well-being indicators such as domestic violence, household wealth, health-care access and decision making power in the household.

In the literature, divorce is used to indicate a unstable match. India has the lowest divorce rates in the world, (Jacob and Chattopadhyay, 2016), therefore, we cannot use it as an indicator of stability. Instead, we use domestic violence post marriage to signal stability. We find a drop in the domestic violence experienced by women due to an increase in education. Next, we check how education affects wealth and healthcare access post marriage. In the matching framework there exits assortative matching on men's income and women education. We also find that educated women are more likely to be matched in the high wealth percentile households. Further, there is improvement in their health care access. Education leads to an increase in hospital deliveries, access to antenatal care and contraceptive use by 26 percent, 12 percent and 27 percent respectively. However, there is no change in decisions making power regarding spending their earnings and big household purchases. Overall these indicators suggest an improvement in the well being of the educated women. This implies that the matching is stable as educated women benefit from the match.

We then investigate how the age at marriage changes if the opportunity cost of being married increases. Since education is valued on the labour market, we want to study if the availability of this outside option will significantly affect the timing of marriage for educated women. While the female LFP in India is well below 30%, there is a significant variation across the country (Pande et al., 2017). We use district wise average female wages and female LFP to measure the labour market returns to education. We interact both these variables with women's education and use DPEP as an IV for education around the cut-off. We find that a 100 rupee increase in women's wages leads to an increase in age at marriage for educated women by 0.2 years or about one and a half month. Similarly, the age at marriage rises for an increase in female labour force participation.

We perform a number of robustness checks for validity of our main estimate of age at marriage. First, we test whether the younger cohort who have not completed the marriage cycle and are yet to be married in the sample, influence our estimate of age at marriage. In our main specification we use DHS 2015-16 sample in the age group of 15-40 as rest of the population is too old to change their schooling decision. But while estimating the impact of age at marriage the younger cohort who are yet to be married can bias the estimate. In India, by the age of 25 more than 96 percent of the individuals are married in the DHS sample. We restrict our sample to the age group of 25-40. This would only include individuals who have completed their marriage cycle. Table 11 shows the impact of education on age at marriage for the cohort in the 25-40 age group. We find the age at marriage falls for this sample as well.

Second, the DPEP program affected both men and women (Khanna, 2015). We want to check how the increase in men's education affected their age at marriage. Using similar IV specification, we estimate the impact of education on husband's age at marriage. We find the husband's age at marriage does not change due to increase in education (table 13).

This indicates that the impact is not a common trend for both men and women but it is specifically for women. Next we restrict our sample to couples where only women were affected and men were not affected by the program. This allows us to isolate the affect of the program only through increases in women's education and not of men. These are men who were too old to change their schooling decision when the program was launched. On an average there is 4 year difference between husband and wife's age in the sample. Thus, the restricted sample is not too different from an average couple in full sample. Even in this sample we observe fall in the age at marriage.

Third, the IV method uses a fix bandwidth from the first stage (table 6). To check the robustness of the estimate, we use various bandwidth. As shown in table 12, we find the impact of age at marriage is still negative and significant and does not vary with change in bandwidth. Fourth, we also estimate the model using a difference-in-difference strategy. Here, we compare DPEP districts to non-DPEP districts and cohort that received the program to cohort that was too old to change their schooling decision. The old cohort has individuals in the age group of 40-49. We restrict our treatment cohort to 30-40 who were exposed to the program and completed their marriage cycle. We find that the DID estimator is negative but not significant (table 14). The effect is smaller than the IV-LATE estimate.

This paper contributes to the extensive literature on the marriage market returns to women's education. Women's education has been positively linked to husbands earnings and her own consumption through assortative mating in developed countries (Attanasio and Kaufmann, 2017; Chiappori, Dias, et al., 2018; Lefgren and McIntyre, 2006). With the schooling expansion in developing countries, there is evidence on an increased educational homogamy (Boulier and Rosenzweig, 1984; Permanyer et al., 2013; Smits and Park, 2009)[1]. There is also evidence on the diminishing returns to education as men do not place importance on the woman's intelligence or ambition over physical attributes (Fisman et al., 2006; Hitsch et al., 2010; Low, 2014; Wahhaj, 2015).

[1]See Anukriti and Dasgupta (2017) for an excellent review on marriages in developing countries.

Several studies have looked at the relationship between education of women and marriage and fertility decisions (Akresh et al., 2018; Boulier and Rosenzweig, 1984; Breierova and Duflo, 2004; Esteve et al., 2013; Gyimah, 2009; Singh and Samara, 1996; Zha, 2019). In countries with stricter social norms and low perceived returns to female labor force participation , parents invest in daughter's education mainly for a prospective match. In this context, we provide additional evidence on the impact of primary schooling expansion on marriage outcomes specifically, the woman's age at marriage. This is relevant as other studies have shown that interventions that might be beneficial in a developed country setting might lead to unintended consequences for certain groups depending on the economic environment or the norms (Ashraf et al., 2020; Bau et al., 2020).

This paper also adds to the literature on the long term effects of schooling reforms on women's education (Duflo, 2001). Finally, this paper contributes to the literature on the long term impact of the DPEP program (Azam and Saing, 2017; Khanna, 2015; Sunder, 2020). Previous papers look at the effect of DPEP on health and educational outcomes of women and their children. We extend this literature by providing evidence on the influence of this policy on marriage timing of women.

The rest of the paper proceeds as follows. Section 2 provides background information of the DPEP. Section 3 describes the data. In section 4 we present the conceptual framework. Section 5 and 6 provides the estimation strategy and results respectively. Section 7 concludes the paper by discussing the key findings and steps ahead.

2 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 reducing gender and socio-economic inequality. Financing of the program was based on a 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, 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 lead 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, establishing academic resource centers, to in service teacher training, textbook and curriculum renewal (Sipahimalani-Eao and Clarke, 2003). The program also focused on decentralised management of elementary education with districts as the main administrative unit. To ensure that a large part of the funds were 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 39,500 new schools and more than 15,000 Early Childhood Centers were built.

An important feature of the program was that it was targeted to districts with poor educational outcomes. There were two main criteria which were used to select districts under the DPEP. First, the districts with 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 into 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 and Glinskaya, 2002). More recent studies provide evidence of the policy on education levels after the completion of the program. Azam and Saing (2017) use difference-in-difference method to estimate the impact of the policy on the probability of completed primary education and years of schooling. While, Khanna (2015) uses an 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.

3 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 et al., 2020; Jayachandran, 2017). The NFHS is a nationally representative survey carried out under the aegis of he Ministry of Health and Family Welfare (MoHFW), Government of India. The survey includes data on fertility, health, and family welfare for the country at individual level. The sample is generated using the stratified two-stage sampling method with the 2011 census as the sampling frame. Primary Sampling Units consists 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 age 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 years 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 543,023 eligible women. Out of these, 358,303 women are married in the sample (69 percent) and 316,728 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 18 (average age at marriage for women is 18.5 years) and have their first child by age 20-21. Table 1 has detailed descriptive statistics for all variables including marriage, fertility, household indicators and surplus variables (women health access, domestic violence etc.). Table 2 has definitions of each variable used in the analysis.

4 Estimation Strategy

The decision of an individual to invest in education is correlated with various unobserved family, social and individual characteristics which might also effect 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 endogenity 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 regression discontinuity framework similar to Khanna (2015). The identification of the causal effects of DPEP program comes from the assumption that all other factors determining the outcomes are continuous with respect to female literacy (Lee and

Lemieux, 2010; Van der Klaauw, 2008).

There is imperfect compliance to 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" RD can be applied to estimate treatment effects. We estimate the first stage relationship between the running variable and treatment status in the close neighbourhood 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 which takes value 1 if the individual belongs to a district which got DPEP. $X_{id} \leq c$ is an indicator for whether the individual lives in a district whose centered female literacy rate is less than c (where $c = 0$). $f(X_{id})$ is a function used to flexibly model X_{id}, the centered female literacy score. h_n is bandwidth selected using CCT methodology of *rdrobust* package (Calonico et al., 2017). In the second stage we estimate equation 2,

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

where 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 and $g(X_d)$ is again a function used to flexibly model X_d.

The RDD specification in equation 2 measures the effect of the DPEP program on education and age at marriage. We want to estimate the effect of education on the age at marriage. The DPEP assignment rule can be used as an instrument to identify the causal effect of education. We create an indicator variable which takes value one if the district is below the average literacy cut-off and zero otherwise.

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

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

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

In equation 3, the instrument $1[X_d]$ captures the discontinuity in the relationship between education $Educ_{id}$, and district average 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 neighbourhood of the cut-off. In equation 4, $\hat{Educ}_{id}$ 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. In all our specifications standard errors are clustered at the district-age level.

4.1 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 neighbourhood 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 and. The DPEP program was introduced for the first time in the year 1994. As the criteria for being eligible for DPEP funding was based on a predetermined variable (female literacy rate as per 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 7, we can see that there is no discontinuity in the assignment variable. Further, to the best of our knowledge no other government program used female literacy rate for program eligibility.

Finally, we provide balance test on predetermined variables that would otherwise bias the estimated parameters (table 3). We use the district level data of DHS 1991-92 to estimate the difference in the pre-determined variables using the RDD method discussed above. The RDD coefficients are not significantly different from zero.

5 Results

Our main results examine the effect of education on women's marriage market outcomes like age at marriage, age when first child was born, and total fertility. We first show the effect of DPEP on the years of education of women. Table 4 reports the estimated coefficient from our RDD specification in equation 2. We find that the policy had a positive effect on years of schooling. The RD estimate shows that on an average, women in the treated district completed 1.5 more years of education.

In Table 5 we report our main results using the RDD method first. We find that the program lead to a decline in the age at marriage of woman by around 0.83 years (column 2) or nearly 9 months. This implies that women in the treated districts are married off within 6 months of reaching the legal age of marriage. In column 3, we see that the age at which women have their first child also reduces by nearly half a year. The RDD coefficient for total children ever born to the woman is negative and insignificant.

The RDD method gives us the average effect of the program on women in the treated districts. In other words, the estimates imply that on an average, districts that received treatment observe a decline in women's age at marriage. But, this does not imply that the decrease in age at marriage is due to education. To check if the age at marriage is falling due to increase in woman's education, we use the 2SLS approach as shown in section **??**. We present the reduced form estimates using 2SLS in table 6 and 7. In the first stage we use DPEP as an instrument for education around the female literacy cut-off.[2] Table 6 shows the

[2] We use bandwidth from the first stage RDD specification which is estimated using CCT's MSE-optimal

second stage results of the impact of education on age at marriage using the IV estimation. The IV estimates show that an increase in education due to DPEP is associated with a fall in the age at marriage by nearly 9 to 15 months. The results imply that educated women in the treated districts are married within 6 months of reaching legal age of marriage, 18. We see a similar decrease of 10-14 months in the age at which women give birth to their first child. The educated women are likely to have fewer children than the less educated women.

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 increase in the surplus within marriage for the educated woman. An increase in education should be followed with an increase in the surplus, if education of women is a preferred attribute on the marriage market. We use a similar IV framework as discussed in the section **??** to identify the impact of women's education on their post marriage well being indicators. We focus on three important indicators - experience of domestic violence their health status post marriage and their decision making power.

6.1 Domestic violence

The stability of marriage is usually measured by the divorce rates. In India, since the divorce rates are very low. Hence, it does not provide a good measure of stability of the match. Instead, we use domestic violence post marriage as an indicator 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, emotional violence or control behaviour by partner. It can be used as a direct measure of the conflict within marriage. We find that the probability of *Any*

bandwidth framework. We have bandwidth of 4.7 for the IV specification.

Violence decreases due to increase in education. As shown in table **??**, the drop in *Any Violence* is substantial, closing on around 22 percent of the control mean of 0.27. The loss of significance could be due to a smaller sample size.[3] 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 coefficient in this specification suggests that due to education fewer women justify violence within marriage. The reduction both in the experience and justification of domestic violence indicates that with increase in education a more stable match is achieved.

6.2 Wealth and Health

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

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

Second, health care access is measured using hospital delivery, antenatal care and use of contraception. We present these results in columns 2-4 of table **??** .We find there is 26 percent increase in the hospital delivery post marriage due to education. There is 12 percent increase in the antenatal care access for educated women post marriage. The use of contraception also increases by 27 percent for the educated women. These measures indicate improved health care access for the women post marriage.

[3] In DHS, a random sub-sample was used for the domestic violence module

6.3 Decision making power

Lastly, we also check if there is any change in the decision making power of the women post marriage. Given there is less autonomy for women in the decision making (Misra, 2006). A stable match would expect an increase in the decision making power for the educated women.

We use following purchasing decision making indicators, person who decides on spending the women's own earning, person who decides on the women's healthcare spending, and person who decides on major household purchases. We create a binary variable with value one if the women is involved in the decision making else zero as shown in table **??**. Using the similar IV specification (as in section **??**), we find education does not change the decision making power for the women significantly in own earnings, household purchases and health care spending. Most of the indicators show the stability of the match post marriage for the educated women.

7 Theoretical Framework

The economic analysis of marriage market is usually analyzed using either frictionless matching framework or search models. In search model, frictions are important. It involves search cost and discounting the risk of never finding a partner. Matching models assumes frictionless environment. It assumes each woman has access to pool of all potential men with perfect knowledge of the characteristics of each of them. In the context of India, marriage migration for the women is the norm. Usually, women leaves her place of origin to join her husband's family. However, 73% of the women stay within their birth district after marriage (Beauchamp et al., 2017). These marriages are predominantly within 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 very strong. So there will be full information available to the family about the match especially within a district. Given the low marriage migration outside the district and full information available about the match, the use of frictionless matching framework is appropriate for our setting (Chiappori, 2020; Chiappori, Dias, et al., 2018; Low, 2014).

In this paper, we use an ad-hoc model that creates a conceptual framework to understand our empirical findings on age at marriage. We use a transferable utility (TU) framework in a unitary household model.[4] 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 longer fertility cycle, lesser autonomy and perceived high quality. Also, education of women is a desirable attribute in the marriage market due to the inter-generational transmission of health and education. For women's parents, 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 maximising the sum of utilities of men and women. Let the surplus exhibit 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 education of women and 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

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

maximisation and marginal rate of substitution for a specific functional form.

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

8 Labour market returns and age at marriage

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

The labour market returns can be measured by women's wage levels in the district, an intensive margin measure, and female labour 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 labour 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 similar IV specification as discussed in the section **??**, where DPEP is used as an instrument for education. To measure the impact we interact the DPEP variable with wage level. In table 15, see a positive coefficient for the interaction between education and district level women's wage. It implies there is delay in the age at marriage by 0.1 years as the weekly wage increases by 100 INR for the women i.e. equivalent to 25 percent of the average weekly wage. The outside option for the women plays an important role in the decision of the marriage. With increase in the labour market returns there can be delay in the age of marriage.

9 Robustness checks

The DPEP cut-off provides with a good instrument to estimate the impact of education on age at marriage. But, the estimation process relies on some assumption such , bandwidth selection and cohort selection to test the impact on age at marriage. In this section, we address these concerns using various specification. We find there is fall in age at marriage for women due to increase in education under all specification.

In the main sample we use cohort from 15-40 age group in the year 2015. The DPEP program was launched in 1994-2002. In 2015, there can be some individuals who are in the marriageable age or yet to finish their marriage cycle. For instance, an individual born in 1994 will be 21 years old in 2015. Women in the sample take at most 25 years to get married.[5] So the individual could get married at age of 23, which we have not accounted for in the sample. This leads to censoring bias in the sample. To overcome this we sub-sample our data to 25-40 years and estimate the impact on age at marriage. This cohort of 25-40 will only include cohort which has completed their marriage cycle. Table 11 compares the impact on age at marriage for different cohort subset. Column 2 shows the impact of cohort 25-40. The age at marriage decreases by around 1 year due to increase in education.

DPEP program has an impact on the men's education as well. This makes it difficult to understand the channel through which education has an impact on age at marriage. For this we check the impact of the education on husband's age at marriage. DHS has information on husband's characteristics. This sample survey was conducted on randomly drawn sample from the full women sample. Using similar IV specification, we find there is no impact of education husband's age at marriage as shown in table 13. This implies that due to increase in education only women's age at marriage has changed and not men's. Next, we also check the impact for a specific cohort where only women were exposed to the program and men were not exposed to the program. This would imply during the implementation of program men were too old to change their decision and women were exposed to the program. This

[5] 96 percent in the sample get married by the age of 25.

sample would be similar to average sample because on an average there is 4-5 years difference in age of husband and wife. Column 4 in table 11 shows the impact on this specific cohort. The impact on age at marriage is negative. Due to small sample size we lose significance of our estimate.

In our main IV specification, we use the bandwidth from the first stage. We estimate the impact of DPEP on education using non-parametric setting by Calonico et al. (2017). It uses mean square error (MSE-RD) method to fix the optimal bandwidth. In the first stage we have bandwidth of 4.7. We use this bandwidth in all our IV specification. Here, we check the impact on age at marriage by changing the bandwidth specification. In table 12, we show the impact for bandwidth 4, 6 and 7 percent. We find that the impact on age at marriage is still negative and significant. It does not vary due to change in bandwidth.

Next, we estimate the model with difference-in-difference strategy. This estimation would allow us to capture the intention to treat effect. Here, we compare DPEP districts to non-DPEP districts and cohort that received the program to cohort that was too old to change schooling decisions. The treated cohort is individuals aged 30-40 and the control cohort is individuals aged 41-49.

$$Y_{id} = \beta_0 + \beta_{did} Cohort_{id} \times DPEP + \alpha_d + \epsilon_{id} \tag{5}$$

From table 14, we find that the age at marriage for women in DPEP districts decreases by 0.05 years. The effect is not significant but negative and smaller than the IV-LATE estimate from table 11.

10 Conclusion

In this paper we study the relationship between women's education and the age at marriage. We estimate this by exploiting the quasi-random variation created by a large scale education intervention called DPEP that targeted districts with low female education.

We build a transferable utility framework on the lines of (Low, 2014) wherein we assume that women are characterised by their education and their age and men are characterised by their income. Existing evidence suggests men prefer to marry younger brides, hence, we allow men's utility to decrease with women's age at marriage. Given the men's preference, our framework predicts that women with more education will tend to improve their returns from marriage by finding a match at a younger age. Our empirical findings show that with an increase in female education due to DPEP, the age at marriage decreased by nearly 0.44 years or by 5 months. This implies that the in the treated districts women who completed primary schooling are more likely to be married within a year of reaching legal age. These women are have fewer children and have their first child earlier than women who do not complete primary school. Our results indicate that surplus obtained from marriage for educated women is higher than uneducated women when labour market prospects are scarce. However, we also see that as women's labour market returns increase, they delay marriage. Contrary to existing evidence that shows a positive relation between female education and delay in marriage, our findings have important implications for policy. In countries where women traditionally have early marriages and do not work outside home, education would lead to a delay in marriage when labour market opportunities for women increase.

11 FIGURES

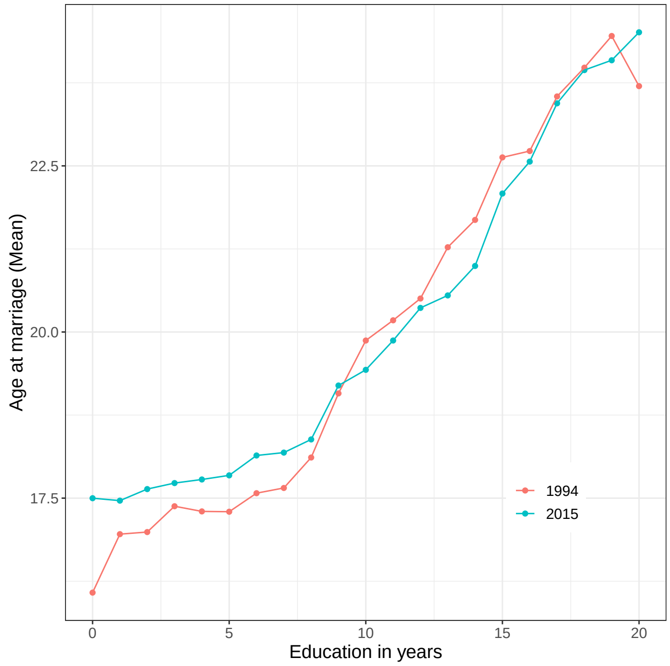

Figure 1 Education vs. age at marriage

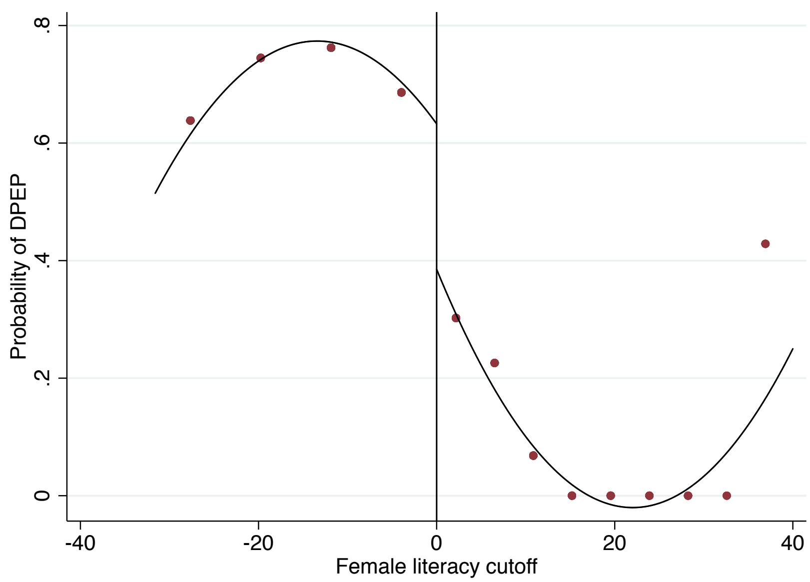

Figure 2 Probability of receiving DEPP

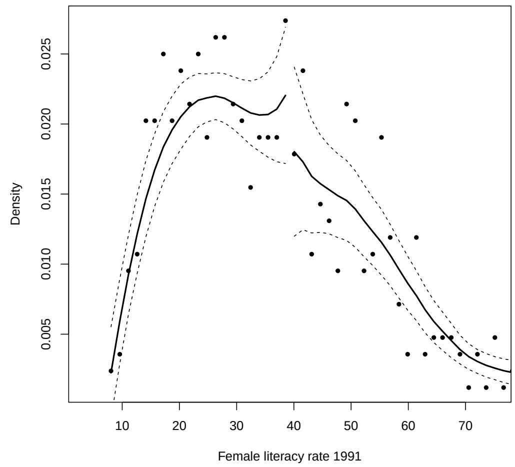

Figure 3 Mccrary Test

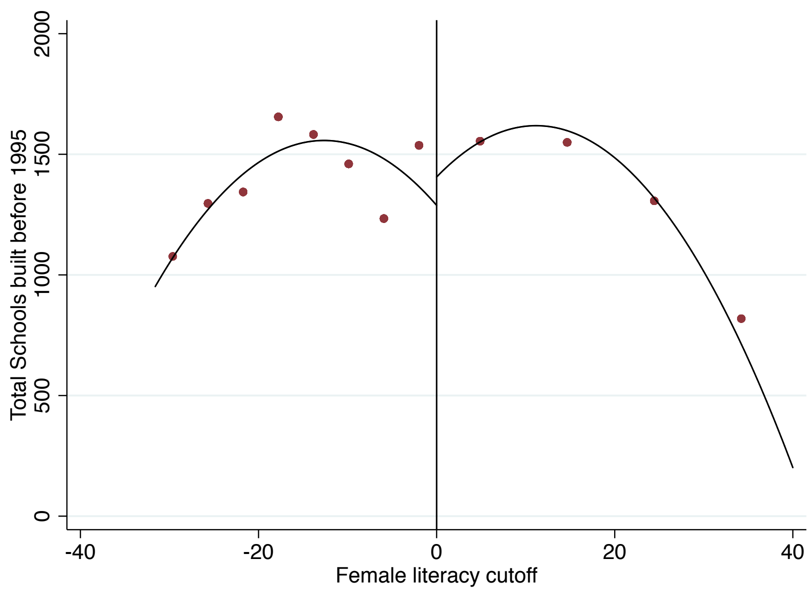

Figure 4 Balance test: Schools built before 1995

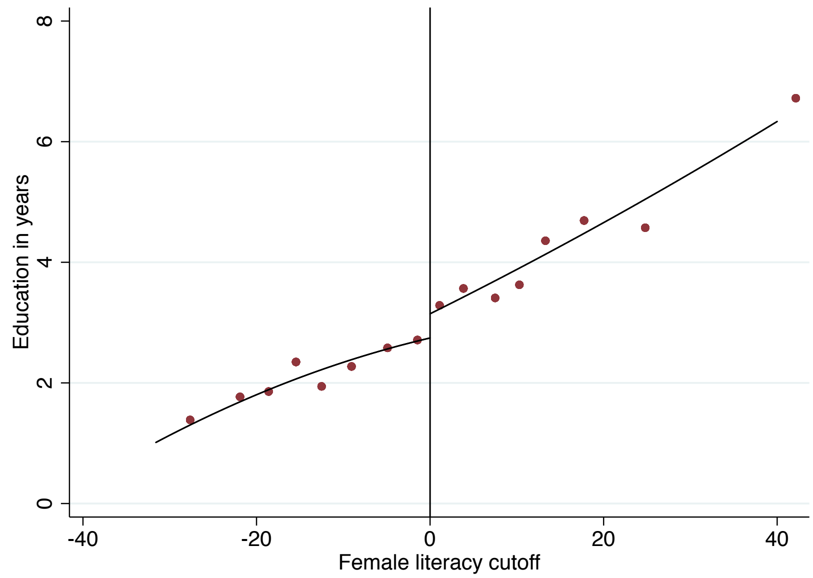

Figure 5 Balance test: Education

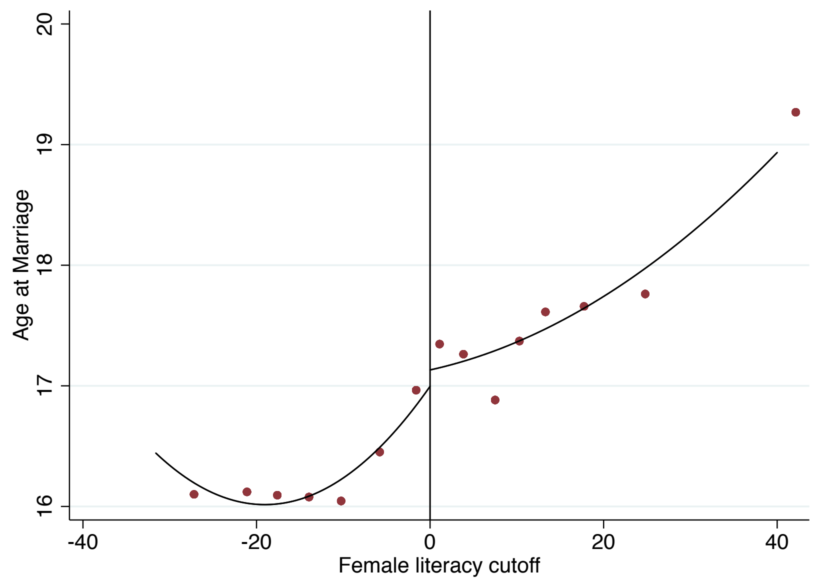

Figure 6 Balance test: Age at marriage

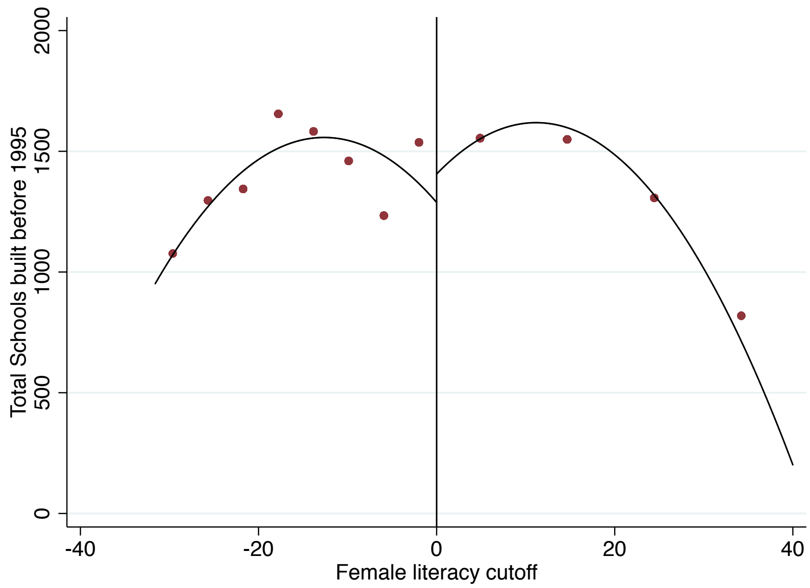

Figure 7 Balance test: Schools built

11 TABLES

Table 1 Descriptive statistics

	N	Mean	SD	Min	Max
DHS, 2015-16					
Marriage and fertility					
Age at marriage	358,303	18.65	3.73	10	40
Age at first birth	316,728	20.63	3.41	15	40
Total children	543,023	1.46	1.56	0	15
Background variables					
Woman age	543,023	26.03	7.14	15	40
Education in years	543,023	7.49	5.01	0	20
HH. size	543,023	5.94	2.69	1	41
Ever married	543,023	0.69	0.46	0	1
Ever gave birth	543,023	0.60	0.49	0	1
Partner Age	63,040	33.77	7.28	15	70
Partner Education	65,241	8.00	4.86	0	20
Partner Age at marriage	62,576	23.37	4.75	10	40
Surplus variables					
Own earning decision	13,289	0.82	0.39	0	1
Health decision	543,023	0.09	0.28	0	1
Purchase decision	543,023	0.08	0.28	0	1
Faced any violence	48,623	0.32	0.46	0	1
Justifies violence	93,289	0.39	0.49	0	1
HH. Wealth	543,023	0.38	0.49	0	1
Hospital deliveries	181,160	0.78	0.41	0	1
Antenatal care received	179,729	0.83	0.38	0	1
Use contraception	381,378	0.56	0.50	0	1
NSSO, 2005					
Median District wage (Women)	488,379	414.30	445.45	90.00	3,000.00
Median District LFPR (Women)	493,474	0.36	0.16	0.00	0.79
Marriage squeeze	493,474	140.78	72.61	24.32	700.00
DISE, 2005					
Schools built before 1995	511,582	1,343.87	819.25	16	5,196
Census, 1991					
DPEP	543,023	0.40	0.49	0	1
Female lit. rate 1991 (centered)	467,687	−3.12	17.07	−31.60	54.70
Sex ratio 1991	377,404	943.64	34.09	851.94	1,079.71
States	36				
Districts	632				
Observations	543,023				

Notes: Summary statistics for four datasets combined. DHS (2015-16): Sample from woman questionnaire for all those who were young in 1994-2005, DISE (2005): District level school indicators, Census of India (1991): District level Primary census abstracts. NSSO (2005), Employment Unemployment Survey. The combined data consists of total 543,023 observations and 632 districts (including splits) out of which 267 got DPEP and remaining did not.

Table 2 Description of variables

DHS, 2015-16	
Marriage market variables	
Age at marriage	Age at start of first marriage or union.
Age at first birth	Age of the respondent at first birth.
Total children	Total number of children ever born.
Background variables	
Woman age	The present age of the woman.
Education in years	Education in single years.
HH. size	Total members of the household.
Ever married	Dummy for woman who ever got married.
Ever gave birth	Dummy for woman who ever gave birth.
Partner Age	Age of the respondent's husband or partner.
Partner Education	The current husband or partner's education in single years.
Partner Age at marriage	The age at marriage of the current husband.
Surplus variables	
Own earning decision	Person who decides how to spend the woman's own earnings
Health decision	Person who decides on the respondent's health care
Purchase decision	Person who usually decides on large household purchases
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.
HH. Wealth	Wealth category post marriage
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
NSSO, 2005	
Median District wage (Women)	The median of individuals weekly wages at district level.
Mean District LFPR (Women)	The average LFPR at district level using the current weekly activity status.(Total women age 15-65 working or looking for work/Total women age 15-65)
Marriage squeeze	Ratio of unmarried women age 15-19 to unmarried men age 20-24.
DISE, 2005	
Schools built before 1995	Total schools built before the year 1995.
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).
Sex ratio 1991	Total number of females per thousand males.

Notes:

Table 3 Balance test covariates

	(1) Education	(2) Age at marriage	(3) Schools built	(4) Sex ratio	(5) Total children
Robust	-1.471	-1.254	720.203	9.333	-0.113
	[1.526]	[1.396]	[445.564]	[39.820]	[0.387]
Sample Mean	3.04	16.90	584.68	942.58	2.64
BW districts	209	135	117	174	189
Bandwidth	14	10	8	12	12
VCE method	NN	NN	NN	NN	NN
BW type	mserd	mserd	mserd	mserd	mserd

Notes: 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 district level. We use nearest neighbour (NN) cluster robust standard errors at district-age level.
$^{**}p<0.05$;$^{***}p<0.01$

Table 4 Impact of DPEP on education

	(1) Years of education
RD Estimate	1.48**
	[0.72]
Sample Mean	7.49
Obs.	467687
BW type	mserd

Notes: Here we show the robust estimate for the impact of DPEP on education. We use fuzzy RDD to estimate the impact of the program on education (ibid.). The bandwidth selection is done using data driven mean square error (MSE-RD) optimal bandwidth methodology. For the above specification we get bandwidth of 4.7. It includes 54 district below the cut-off and 44 districts above the cut-off. We use nearest neighbour (NN) cluster robust standard errors at district age level. $^{**}p<0.05$;$^{***}p<0.01$

Table 5 Impact of education on marriage market outcomes for women - RDD estimates

	(1) Ever Marry	(2) Age at Marriage	(3) Age at First birth	(4) Total child
RD Estimate	-0.03	-0.83**	-0.46*	-0.02
	[0.08]	[0.40]	[0.28]	[0.38]
Control Mean	0.68	19.36	21.21	1.40
Obs.	467687	302335	262735	467687
BW type	mserd	mserd	mserd	mserd

Notes: Here we show the robust estimate for the impact of DPEP on marriage market outcomes. The dependent variables in the columns 1 to 4 are *Ever getting married, Age at Marriage, Age at first birth, and Total Children ever born* respectively. We use fuzzy RDD to estimate the impact of the program on education (Calonico et al., 2017). The bandwidth selection is done using data driven mean square error (MSE-RD) optimal bandwidth methodology. We use nearest neighbour (NN) cluster robust standard errors at district age level. **p<0.05;***p<0.01

Table 6 Impact of education on age at marriage

	(1) Age at Marriage
Education	-0.44***
	[0.17]
Observations	58140
Control Mean	18.65
CD Fstat	37.63

Notes Here we show the robust estimate for the impact of education on age at marriage. We use DPEP cut-off as an instrumental variable for education. We use the first stage bandwidth of 4.7 around the cut-off. This includes 54 districts below the cut-off and 44 districts above the cut-off. We use nearest neighbour (NN) cluster robust standard errors at district age level. **p<0.05;***p<0.01

Table 7 Impact of education on marriage market outcomes

	(1) Age at First Birth	(2) Total Child
Education	-0.22	-0.06**
	[0.16]	[0.03]
Observations	51502	87991
Control Mean	20.63	1.46
CD Fstat	26.04	97.05

Notes Here we show the robust estimate for the impact of education on marriage market outcomes. We use DPEP cut-off as an instrumental variable for education. We use the first stage bandwidth of 4.7 around the cut-off. This includes 54 districts below the cut-off and 44 districts above the cut-off. We use nearest neighbour (NN) cluster robust standard errors at district age level. **p<0.05;***p<0.01

Table 8 Impact of education on domestic violence

	(1) Any Violence	(2) Justifies Violence
Education	-0.22***	-0.14***
	[0.08]	[0.03]
Observations	7688	14485
Control Mean	0.27	0.38
CD Fstat	7.57	33.38

Notes 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 variable *Fem. Lit.* is the districtwise female literacy in 1991. **p<0.05;***p<0.01

Table 9 Impact of education on wealth and healthcare access

	(1) Household Wealth	(2) Hospital Delivery	(3) Antenatal care	(4) Contraception
Education	0.15***	0.07***	0.05***	0.14***
	[0.01]	[0.01]	[0.01]	[0.03]
Observations	87991	28210	27897	61702
Control Mean	0.48	0.82	0.87	0.57
CD Fstat	97.05	65.09	63.93	35.45

Notes This 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 variable *Fem. Lit.* is the districtwise female literacy in 1991. **p<0.05;***p<0.01

Table 10 Impact of education on spending decisions within household

	(1) Own Earnings	(2) Health care	(3) Purchases
Education	-0.19	-0.01*	-0.01
	[0.56]	[0.01]	[0.01]
Observations	2358	87991	87991
Control Mean	0.85	0.09	0.09
CD Fstat	0.14	97.05	97.05

Notes: This table shows the IV estimates for the impact of education on decision making within household. The dependent variables in columns 1 to 3 are *person who decides on spending the woman's own earning, person who decides on the woman's healthcare, person who decides on major household purchases* respectively. The reference for all columns is that the husband or someone else in the household takes decisions vs the woman taking the decisions alone or jointly with the husband. The variable *Fem. Lit.* is the districtwise female literacy in 1991. **p<0.05;***p<0.01

Table 11 Impact of education on age at marriage: Cohort subset

		Old Cohort		Only Women
	Main	25-40	30-40	Treated
Education	-0.44***	-1.06**	-2.78	-0.26
	[0.17]	[0.41]	[1.93]	[0.38]
Observations	58140	39385	22939	2336
Control Mean	18.78	19.07	19.09	18.47
CD Fstat	37.63	14.43	2.76	6.17

Notes Here we show results for robustness checks on the impact of educaiton on age at marriage. In column 2 and 3 we use old cohort in the age group of 25-40 and 30-40 repectively. In column 4 we use cohort where only women were treated in the program and men were too old to change their schooling decision. We use nearest neighbour (NN) cluster robust standard errors at district-age level. **p<0.05;***p<0.01

Table 12 Impact of education on age at marriage: Flexible specification

		Bandwidth		
	Main	4	6	7
Education	-0.44***	-1.17***	-0.76***	-0.48***
	[0.17]	[0.40]	[0.28]	[0.16]
Observations	58140	51364	72784	83379
Control Mean	18.78	18.76	18.77	18.67
CD Fstat	37.63	16.52	20.84	43.69

Notes Here we use different bandwidth specification to estimate the impact of education on age at marriage. The initial bandwidth of 4.7 includes 54 district below the cut-off and 44 districts above the cut-off. We use nearest neighbour (NN) cluster robust standard errors at district-age level. **p<0.05;***p<0.01

Table 13 Impact of education on husband's age at marriage

	(1) Husband's age at marriage
Education	0.21 [0.23]
Observations	9746
Control Mean	23.37
CD Fstat	16.18

Notes Here we estimate the impact of education on husband's age at marriage. This data is randomly selected sample from the women questionnaire. Hence, there are lower number of observations in the analysis. We use nearest neighbour (NN) cluster robust standard errors at district-age level. **p<0.05;***p<0.01

Table 14 Impact of education on age at marriage: Difference-in-Difference

	(1) DID
DPEP $\times$ Cohort	-0.05 [0.03]
Obs.	299074

Notes Here we estimate the impact of education on age at marriage using DID strategy. We compare DPEP districts to non-DPEP districts and cohort that received the program (30-40 age group) to cohort that was too old to change their schooling decision. We use nearest neighbour (NN) cluster robust standard errors at district-age level. **p<0.05;***p<0.01

Table 15 Impact of education on age of marriage: wage levels

	(1) Wage
Education	-0.7872**
	[0.4011]
Education × Wage	0.0009***
	[0.0003]
Wage	-0.0056**
	[0.0022]
Observations	57648
Control Mean	19.51
CD Fstat	7.00

Notes **p<0.05;***p<0.01

Table 16 Impact of education on age of marriage: marriage squeeze

	(1) Marriage squeeze
Education	-0.2692
	[0.2666]
Education × Marriage Squeeze	-0.0052**
	[0.0024]
Marriage squeeze	0.0274*
	[0.0152]
Observations	58140
Control Mean	19.51
CD Fstat	22.84

Notes **p<0.05;***p<0.01

A 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 and 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 (E. Fletcher et al., 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 equilibrium 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 $R = \frac{2\delta}{\alpha}$.

A.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.

A.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.

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

A.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, et al., 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.

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

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