# Age at marriage: Evidence from large scale education program

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**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 as an instrument for education. In contrast to the literature, we find a decrease in the age at marriage by 1.3 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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# 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; Pierre-Andre Chiappori 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. 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 there 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 DPEP 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 1.3 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 (Pierre-André 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. Educated women are also more likely to make important decisions regarding spending their earnings and big household purchases. 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 0.12 years or about one and a half month. Similarly, the age at marriage rises for an increase in female labour force participation.

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; Pierre-André Chiappori et al., 2018; Lefgren and McIntyre, 2006). With the schooling expansion in developing countries, there is evidence on an increased educational homogamy in developing countries (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).

Several studies have also shown that educated women delay marriages, however, it is not a universal phenomenon (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 female LFP, parents invest in daughter's education mainly for a prospective match (Adams and Andrew, 2019; Field and Ambrus, 2008). In this context, we provide causal evidence on the impact of primary schooling expansion on marriage outcomes specifically, the woman's age at marriage.

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

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 (ibid.).

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. 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.[2] 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.[3]

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

[2]Census of India, 1991
[3]NEUPA Archives

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 Theoretical Framework

In this paper 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

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

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

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

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

# 5 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 exploit the discontinuity around the cut-off 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).

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. As opposed to a "sharp" RD where the probability of treatment jumps from 0 to 1, the fuzzy RD design allows for a smaller jump in the probability of treatment at the thresholdDue to imperfect compliance we are estimating a LATE, i.e the effect relevant for the average-literacy district induced into taking up treatment.

Assuming that the treatment assignment is a good as random around the cut-off, the treatment effect recovered using fuzzy RD are similar to Wald formulation of the treatment effect in an instrumental variables (IV) setting. 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.

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

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 a standard IV setting the causal effects are estimated by assuming that the instrument affects the outcome only through its effect on treatment assignment. Similarly, we assume the indicator variable $X_{id} \leq c$ has no impact on the outcome except by influencing the treatment status $T_{id}$.

In the second stage we estimate equation 2,

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

where $T_{id}$ is the estimated probability of treatment from the first stage. $\tau_{FRD}$ is the main coefficient of interest which gives us the impact of DPEP on the outcome variable and $g(X_{id})$ is again a function used to flexibly model $X_{id}$.

## 5.1 DPEP as an instrument for education

The RDD specification in equation 2 will measure the impact of the DPEP program on the districts which received the program. We are interested in estimating the impact of education on the age at marriage and other marriage market outcomes. Hence, we use an instrumental variable setting to estimate the impact of education. We use DPEP program as an instrument for education around the female literacy cut-off.

The 2SLS approach is shown in the equation below:

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

$$Y_{id} = \zeta + \tau_{IV} \hat{Educ}_{id} + X_{id} + \varepsilon_{id}, \quad c - h \leq X_{id} \leq c + h \tag{4}$$

where $\hat{Educ}_{id}$ is the estimated education due to the program from the first stage. $\tau_{IV}$ is the main coefficient of interest which gives us the impact of education on the outcome variable. The first stage estimates the impact on education due to the DPEP program. The second stage estimates the impact on marriage market outcomes using the estimated education from the first stage. This provides us with a causal effect of education on marriage market outcomes. In all our specifications standard errors are clustered at the district-age level.

## 5.2 Validity checks

In figure 1 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 2, 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.

# 6 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 5.1. We present the reduced form estimates using 2SLS in table 6. In the first stage we use DPEP as an instrument for education around the female literacy cut-off.[5] Table 6 shows the 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.

# 7 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 5.1 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.

[5]We use a bandwidth of 5 for the IV specification

## 7.1 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 Violence* decreases due to increase in education. As shown in table 8, 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.[6] 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.

## 7.2 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 5.1), 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 9). This indicates assortative matching

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

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 9 .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.

### 7.3 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 10. Using the similar IV specification (as in section 5.1), we find education increases the decision making power for the women significantly in both health care spending and household purchases. All the indicators show the stability of the match post marriage for the educated women.

## 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 5.1, where DPEP is used as an instrument for education. To measure the impact we interact the DPEP variable with wage level. In table 11, 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 0.12 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. We find a similar positive increase in the age for educated women in districts where the female LFP is high as shown in table 12.

# 9 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 1.4 years or by 15 months. This implies that the in the treated districts women who completed primary schooling are more likely to be married within six months 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.

# 10 FIGURES

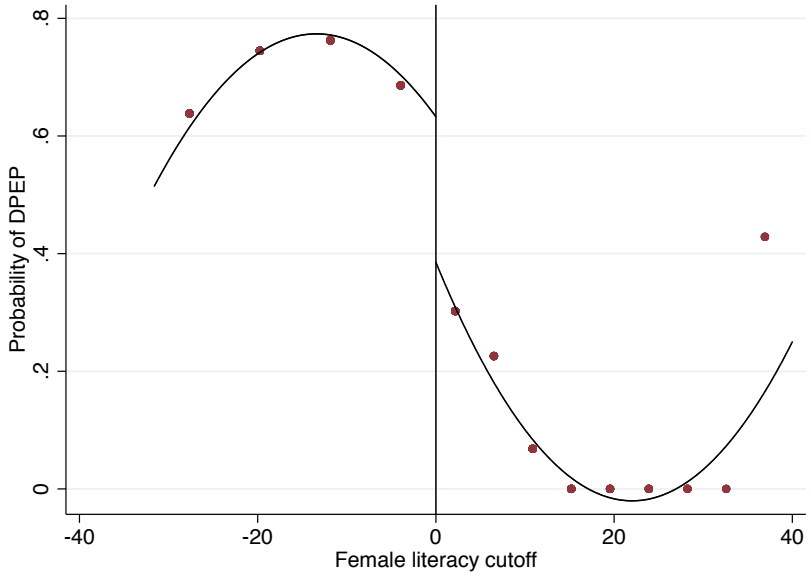


**Figure 1** Probability of receiving DEPP

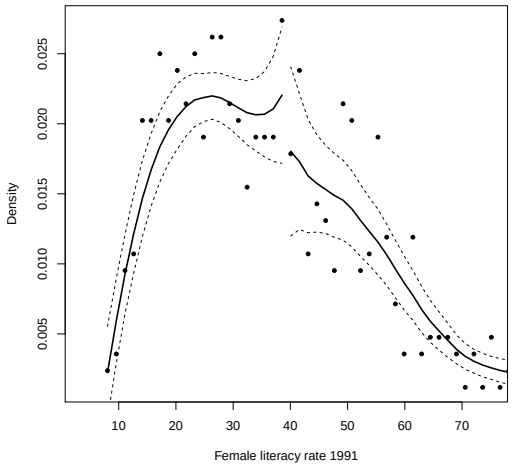


**Figure 2** Mccrary Test

# 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, DHS data 1991-92

| Initial covariates | RD Effect | Robust p-val |
|---|---|---|
| Schools built before 1995 | -278.99 | .888 |
| Sex ratio 1991 | 14.47 | .802 |
| Age of woman | -1.941 | .058 |
| Education in years | -1.344 | .275 |
| HH size | 1.137 | .192 |
| Age at first marriage | -.886 | .465 |
| Age at first birth | -.521 | .593 |
| Total children | .077 | .984 |
| Partner education | -1.245 | .576 |

**Table 4** Impact of DPEP on education

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

*Notes*: This table records the first stage results of the effect of DPEP on education. We use 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)<br>Ever Marry | (2)<br>Age at Marriage | (3)<br>Age at First birth | (4)<br>Total child |
|---|---|---|---|---|
| RD Estimate | -0.03<br>[0.08] | -0.83**<br>[0.40] | -0.46*<br>[0.28] | -0.02<br>[0.38] |
| Control Mean | 0.68 | 19.36 | 21.21 | 1.40 |
| Obs. | 467687 | 302335 | 262735 | 467687 |
| BW type | mserd | mserd | mserd | mserd |

*Notes*: We use nn cluster robuststandard errors at district age level. 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. **p<0.05;***p<0.01

**Table 6** Impact of education on marriage market outcomes for women - IV estimates

| | (1) Ever Marry | (2) Age at Marriage | (3) Age at First birth | (4) Total child |
|---|---|---|---|---|
| Education | 0.05*** | -1.35*** | -1.25*** | -0.77*** |
| | [0.02] | [0.20] | [0.18] | [0.11] |
| Observations | 94310 | 60867 | 52900 | 94310 |
| Control Mean | 0.68 | 19.36 | 21.21 | 1.40 |
| CD Fstat | 42.98 | 74.00 | 73.07 | 42.98 |

*Notes*: We use nn cluster robuststandard errors at district age level. 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. **p<0.05;***p<0.01

**Table 7** Impact of education on marriage market outcomes for women - IV estimates with covariates

| | (1) Ever Marry | (2) Age at Marriage | (3) Age at First birth | (4) Total child |
|---|---|---|---|---|
| Education | -0.01 | -0.77*** | -0.92*** | -0.59*** |
| | [0.02] | [0.15] | [0.16] | [0.08] |
| Female literacy 1991 | 0.00*** | 0.09*** | 0.10*** | 0.02*** |
| | [0.00] | [0.01] | [0.01] | [0.00] |
| Ratio of unmarried w/m | -0.00** | 0.01*** | 0.01*** | 0.00*** |
| | [0.00] | [0.00] | [0.00] | [0.00] |
| District median wage | -0.00*** | 0.00*** | 0.00*** | 0.00*** |
| | [0.00] | [0.00] | [0.00] | [0.00] |
| Distruct average FLFPR | 0.05 | 2.38*** | 2.32*** | 1.07*** |
| | [0.03] | [0.40] | [0.45] | [0.19] |
| Avg. Crime against women | 0.00*** | -0.00*** | -0.00*** | -0.00*** |
| | [0.00] | [0.00] | [0.00] | [0.00] |
| Observations | 85336 | 55075 | 47841 | 85336 |
| Control Mean | 0.68 | 19.36 | 21.21 | 1.40 |
| CD Fstat | 40.46 | 68.35 | 64.32 | 40.46 |

*Notes*: We use nn cluster robuststandard errors at district age level. 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. **p<0.05;***p<0.01

**Table 8** Impact of DPEP on domestic violence

| | (1) Any Violence | (2) Justifies Violence |
|---|---|---|
| Education | -0.06 | -0.00 |
| | [0.12] | [0.08] |
| Observations | 8257 | 15522 |
| Control Mean | 0.27 | 0.38 |
| CD Fstat | 0.83 | 1.51 |

*Notes* This table records the IV estimates for the impact of DPEP 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 healthcare access

| | (1) Household Wealth | (2) Hospital Delivery | (3) Antenatal care | (4) Contraception |
|---|---|---|---|---|
| Education | 0.04*** | 0.26*** | 0.12*** | 0.27*** |
| | [0.01] | [0.04] | [0.02] | [0.04] |
| Observations | 94310 | 30128 | 29791 | 66223 |
| Control Mean | 0.48 | 0.82 | 0.87 | 0.57 |
| CD Fstat | 42.98 | 39.30 | 37.72 | 44.93 |

*Notes* This table records the IV estimates for the impact of DPEP 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 DPEP on spending decisions within household

| | (1) Own Earnings | (2) Health care | (3) Purchases |
|---|---|---|---|
| Education | 0.39 | 0.02** | 0.02** |
| | [0.45] | [0.01] | [0.01] |
| Observations | 2476 | 94310 | 94310 |
| Control Mean | 0.85 | 0.09 | 0.09 |
| CD Fstat | 0.75 | 42.98 | 42.98 |

*Notes*: This table records the IV estimates for the impact of DPEP 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 columnsis 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 of marriage: wage levels

| | (1) Age at Marriage |
|---|---|
| Education × Women's Wage | 0.12*** |
| | [0.02] |
| Education | -1.23*** |
| | [0.18] |
| Women's Wage | -0.79*** |
| | [0.14] |
| Observations | 61288 |
| Control Mean | 19.47 |
| CD Fstat | 54.17 |

*Notes* This table records the IV estimates of the channel through which DPEP has an impact on the woman's age at marriage.**p<0.05;***p<0.01

**Table 12** Impact of education on age of marriage: female labour force participation

| | (1)<br>Age at Marriage |
|---|---|
| Education × Female LFP | 1.18 |
| | [2.52] |
| Education | -3.03** |
| | [1.43] |
| Female LFP | -1.96 |
| | [16.93] |
| Observations | 62389 |
| Control Mean | 19.47 |
| CD Fstat | 4.33 |

*Notes* This table records the IV estimates of the channel through which DPEP has an impact on the woman's age at marriage. **p<0.05;***p<0.01

**Table 13** Impact of education on age of marriage: marriage squeeze

| | (1)<br>Age at Marriage |
|---|---|
| Education× Marriage Squeeze | 0.01*** |
| | [0.00] |
| Education | -2.56*** |
| | [0.35] |
| Marriage squeeze | -0.10*** |
| | [0.02] |
| Observations | 62389 |
| Control Mean | 19.47 |
| CD Fstat | 27.45 |

*Notes* This table records the IV estimates of the channel through which DPEP has an impact on the woman's age at marriage. **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 $\beta$.

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

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 $\delta$ 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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