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Marriage market responses in the wake of a natural disaster in India

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Abstract: This paper examines the impact of the 2001 Gujarat earthquake on age at marriage and other assortative matching outcomes. Using the 2004–05 wave of the India Human Development Survey and employing a difference-in-differences strategy, we document that the earthquake reduced the age at marriage for both men and women and decreased the likelihood of women marrying into wealthier households. Additionally, we find no changes in matching by educational status or in the likelihood of intra-caste and out-of-village marriages. The results are driven by districts that were severely affected by the earthquake in terms of deaths and destruction. Our conjecture is that the negative economic shock pushed parents to marry off their daughters early to save on dowry expenditures. We confirm this underlying mechanism by using a proxy for dowry payments. Our results highlight how the institution of marriage can induce long-lasting demographic changes after a natural disaster.

Key words: marriage, India, Gujarat earthquake, natural disasters, dowry

JEL classification: J12, J16, O53

Tables and figures: at end of paper

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Note: On 18 November, modifications were made to correct the year range in the data sources under the tables.

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1 Introduction

Marriages in India continue to serve as an important social institution, fraught with traditional norms. Marriage is nearly universal, almost always monogamous, and divorce is very uncommon (Chiplunkar and Weaver 2021). Approximately 95 per cent of marriages are family arranged (Rubio 2014), where parents choose their child's spouse based on the caste, religion, and economic standing of the prospective spouse and their family (Allendorf and Pandian 2016). Against this backdrop, we utilize a high mortality, unanticipated negative shock setting—the 2001 Gujarat earthquake—to examine how the age at marriage, matching by education, intra-caste marriage, and geographical location and economic standing of spousal families changed.

We use the 2004–05 wave of the nationally representative India Human Development Survey (IHDS) and exploit variations in district-wise exposure to the earthquake and women's year of marriage in a difference-in-differences (DID) framework. The identifying assumption underlying our empirical strategy is that changes in marriage patterns over time in earthquake-unaffected districts constitute a valid counterfactual for the changes observed in earthquake-affected districts. We establish the credibility of this strategy by examining pre-earthquake trends and conducting falsification tests. Also, importantly, as Gujarat had not witnessed an earthquake since 1956, one with far fewer (under 150) casualties (Mishra 2004), the 2001 earthquake was completely unanticipated.

Our main finding is that the 2001 Gujarat earthquake reduced the age of women and men at marriage by about 11 months over the counterfactual average age of marriage of 19 years and 24 years, respectively. Additionally, we find no significant changes in matching by educational status, the probability of intra-caste marriages, or in the probability of out-of-village marriages. However, we find a decreased likelihood of women marrying into relatively richer households, an indication that parents of daughters may not have been able to attract high-quality matches. These results are driven by districts in Gujarat that were severely affected by the earthquake, where the extent of severity is based on estimates of mortality and destruction of property as given in Lahiri et al. (2001). Our conjecture is that parents, plagued by the negative economic shock induced by the earthquake, responded by marrying off their daughters early to save on dowry expenditures. We confirm this underlying mechanism by utilizing a proxy for dowry payments.

These results have important implications as a woman's marital prospects are strongly correlated with her demographic and economic outcomes. For instance, early and teenage marriage negatively affects women's education and labour force participation, as well as maternal and child health (Chari et al. 2017; Field and Ambrus 2008). It is also associated with low autonomy of women within households and high rates of domestic violence (Jensen and Thornton 2003). Similarly, marital sorting by parental background can have an impact on the intergenerational transmission of socioeconomic conditions and whether people marry out of poverty (Charles et al. 2013).

Our paper contributes to the literature that explores changes in family formation following natural disasters. While there is continued discussion on fertility and human capital effects (for example, Caruso and Miller 2015; Datar et al. 2013; Davis 2017; Nandi et al. 2018; Thamarapani 2021), only a few studies examine the link between natural disasters and marriage markets (Almond et al. 2007; Brandt et al. 2016; Corno et al. 2020; Mobarak et al. 2013).

Our study also provides an understanding of the persistence of deeply entrenched features in Indian marriage markets, even in the wake of natural disasters. The only other paper in the context of a natural disaster in India is the one by Khanna and Kochhar (2019), who examine the marriage

market effects of the 2008 Kosi floods in Bihar. Our results hold similar statistical and economic significance and are externally valid for different natural disasters (earthquakes and floods) with varying levels of casualties and using different datasets in the Indian context.

We also add to the handful of studies that examine the socioeconomic consequences of the 2001 Gujarat earthquake. Lahiri et al. (2001) provide an overview of the overall economic impact of the disaster. While Finlay (2009) finds no significant changes in fertility due to the earthquake, Nandi et al. (2018) find increased childbirth rates and decreased birth-spacing among certain groups.

Finally, this study is also related to an emerging empirical literature on spousal matching. In the context of developing countries, previous work has examined marital sorting primarily in education (Esteve et al. 2012; Lin et al. 2020), but studies have also considered other dimensions like caste, assets brought to the marriage, attributes such as height, and parental background (Banerjee et al. 2013; Borker et al. 2017; Chiappori et al. 2021; Fafchamps and Quisumbing 2005).

Thus, we complement the previous literature by studying the impact of a disaster on age at marriage and matching by education. Furthermore, we are the first to examine whether marital sorting by caste, geographical location, and parental background changes in response to a natural disaster. These outcomes can change, if, for example, the disaster alters the scope of marriage search. Overall, our study helps to provide a comprehensive picture of the demographic consequences of the 2001 Gujarat earthquake by examining its impact on marriage outcomes.

The remainder of the paper is structured as follows. Section 2 provides background information on the 2001 Gujarat earthquake. In Section 3, we briefly review the pertinent literature. Section 4 describes the data and Section 5 outlines the empirical strategy. We then present our results and discuss pre-trend analyses and robustness checks in Section 6. Section 7 elaborates on mechanisms and Section 8 offers conclusions.

2 The 2001 Gujarat earthquake

At approximately 8:46 am on 26 January 2001, an earthquake of magnitude M_w 7.7 (Richter 6.9) struck the Kutch region of Gujarat, a state in western India.[1] Twenty-one out of 25 districts were affected, with varying degrees of intensity. Lahiri et al. (2001) categorize the affected districts into severely and less affected districts by estimating the number of deaths and injured and the damage and destruction of property. While the bulk of the impact lay in the district of Kutch, five other districts (Ahmedabad, Jamnagar, Patan, Rajkot, and Surendranagar) were also considerably impacted. The six *severely affected* districts account for approximately 99 per cent of the deaths and 96 per cent of the injured due to the earthquake, with the highest share of the population toll in Kutch. *Less affected* districts were Amrelli, Anand, Banaskantha, Bharuch, Bhavnagar, Gandhinagar, Junagadh, Kheda, Mehsana, Navasari, Porbandar, Sabarkantha, Surat, Vadodara, and Valsad. Only four Gujarat districts were completely unaffected: Dahod, Dangs, Narmada, and Panch Mahals. Figure 1 provides a visual guide to the districts and the severity of the earthquake's impact in Gujarat.

The earthquake brought large-scale devastation to the region and affected 16 million people. The reported loss of lives was approximately 20,000, around 165,000 people were injured, and more than 200,000 were rendered homeless (Lahiri et al. 2001; Sinha 2001). About 10,000 adults (roughly

[1] M_w denotes the moment of magnitude scale.

equal numbers of males and females) aged between 15 and 59 years died (Lahiri et al. 2001). Nearly 300,000 buildings were destroyed and another 700,000 were damaged (Madabhushi and Haigh 2005). The estimated economic loss was around US$2 billion, and reconstruction and rehabilitation estimates were set at US$1 billion (Sinha 2001).

3 Literature review

3.1 Natural disasters and marriage markets

Natural disasters are usually unpredictable, and these exogenous negative shocks can adversely affect economies and households. Studies show that natural disasters decrease income and consumption expenditure, lower wages, and increase income inequality (Baez et al. 2017; Bui et al. 2014; Mueller and Quisumbing 2011). These events also adversely affect health and human capital accumulation (Caruso and Miller 2015; Datar et al. 2013; Thamarapani 2021). Additionally, in the face of such disasters, women face higher risks to their reproductive health, including increased maternal stress, a reduction in birth-spacing, and an increase in fertility (Behrman and Weitzman 2016; Nandi et al. 2018).

Few studies have examined the marriage market effects of natural disasters. If disasters affect the pool of marriageable individuals, the perceived costs and benefits of marriages could change. Consequently, the number of marriages could fall if individuals become less attractive as mates due to the disasters' negative human capital effects (Almond et al. 2007; Brandt et al. 2016). Conversely, stress-induced attachment could increase marriage rates, and the overall stress of having experienced a catastrophic event could result in more divorces (Cohan and Cole 2002). Weather shocks and disasters can also change the timing of marriage. Khanna and Kochhar (2020) find women's and men's ages at marriage decreased following a flood in India. They surmise that households with sons marry them earlier to smooth consumption by accepting a dowry when faced with the negative economic shock. On the other hand, Corno et al. (2020) document that drought-specific income shocks increase the hazard of child marriages in sub-Saharan Africa but decrease the probability of child marriages in India. They attribute their finding to households using female child marriage as a strategy to mitigate income volatility, bringing it forward in sub-Saharan Africa, where bride-price is expected, and delaying it in India, where dowry is due.

Finally, disasters can also alter the quality of marital matches. For instance, the negative education and labour market outcomes of disasters can affect the matching process of women. Women exposed in utero to the 1959 Chinese famine or the 1970 Ancash earthquake in Peru married spouses with less education (Almond et al. 2007; Caruso and Miller 2015). In Bangladesh, heatwaves push households to marry their daughters into poorer households and to husbands with less education. These households cope with economic hardship by marrying off their daughters to reduce household consumption (Carrico et al. 2020). On the flip side, Mobarak et al. (2013) use the positive wealth shock from the construction of a flood protection embankment in rural Bangladesh to document that brides from protected households marry wealthier households and become less likely to marry biological relatives. They postulate that, as marrying relatives reduces dowry payments, households resort to within-family marriages when they are credit-constrained and therefore unable to pay the dowry up front. By increasing household wealth, flood protection reduces the need to marry relatives, as these households can now afford higher dowries.

3.2 Marriages in India

Despite the documented negative effects on women and children, early marriage has remained resilient in India (Chari et al. 2017; Field and Ambrus 2008; Jensen and Thornton 2003). Child marriage was reported by 58 per cent of women aged 20–49 across India, although considerable regional differences exist (IIPS and Macro International 2007). In Gujarat, marriage rates among females aged 15–19 years declined substantially between 1991 and 2001 but the trend reversed sharply between 2001 and 2011 (Srinivasan et al. 2015). The persistence of female child marriage is attributed to high returns from women's adherence to traditional norms of behaviour such as docility and obedience to husband and in-laws and because daughters are viewed as a burden due to the high costs of providing their economic support or the need to protect and preserve their sexual purity (Jensen and Thornton 2003).

Examining marital sorting on education is also crucial as it has important consequences for gender equality, amplifying inequality across households and the intergenerational transfer of human capital. Following significant strides in female educational attainment, educational hypergamy (women marrying men with higher levels of education) has been declining globally (Esteve et al. 2012). In India, this trend is accompanied by rising hypogamy (women marrying men with less education) rather than homogamy (women marrying men with equal levels of education) as experienced elsewhere (Lin et al. 2020).

Throughout India, there is a strong and persistent preference for marrying within the same caste. One reason is that caste can proxy for the prospective spouse's own and family attributes when screening partners in family-arranged marriages. Another reason, particularly important in rural areas, is that close ties and frequent social interactions within the caste provide well-functioning informal insurance networks for consumption smoothing and risk management (Munshi and Rosenzweig 2016). Consequently, there is a strong resistance to inter-caste marriages, which makes them rare events. Allendorf and Pandian (2016) estimate that only 5–7 per cent of Indian marriages in the 2000s were inter-caste marriages.

The high level of parents' involvement in marital decisions deems marital sorting by parental background important. Such sorting can have implications for the intergenerational transmission of socioeconomic conditions and the role of marriage as a driver for social mobility (Charles et al. 2013). Similarly to caste, marital household wealth can signal socioeconomic and cultural status in family-arranged marriages.

Much of India practices patrilocal exogamy in which women are married outside their natal village and they migrate to join their husband's family in his village (Fulford 2015). Three-quarters of all Indian marriages are within the same district and the mean travel time between a woman's natal and marital households is about three hours (Chiplunkar and Weaver 2021). An examination of this geographical distance is vital as it is predictive of the ease with which women can maintain ties and gain social support from their natal family.

4 Data

The data for our analysis come from the 2004–05 wave of the nationally representative India Human Development Survey (IHDS). The survey collects information on household characteristics such as religion and caste as well as individual characteristics including age, gender, and completed years of schooling. Most importantly, we use the marital history information provided by ever-married women aged 15–49 years in each household.

Ideally, we would like to confine our sample to women residing in Gujarat and compare marriage outcomes in affected and unaffected districts before and after the earthquake. However, as the earthquake affected 84 per cent of the total districts in Gujarat,[2] we include Maharashtra in the comparison group—it is the most economically similar neighbouring state to Gujarat.[3] Thus, our study sample consists of women residing in Gujarat and Maharashtra.

The IHDS records women's year of marriage, and we use this information to categorize women into two groups: a) those who were married after the 2001 Gujarat earthquake and hence whose marriage formations could potentially have been affected, and b) those already married before the disaster. We restrict our sample to marriages between 1996 and 2005, or approximately five years before and after the earthquake. Additionally, we exclude women who have been married more than once as these marriages are likely to differ from first marriages.

Our primary outcome measures are women's and men's ages at marriage. To examine sorting by education, we construct a binary variable that equals one if a husband is more than or equally educated as his wife and that is zero otherwise. We then check for intra-caste matches by considering an indicator for whether a woman's spouse is from the same caste as her. The IHDS collects information on whether a woman married into a lower or higher economic status household. We create an indicator for the relative economic status of marital households for whether her marital household is economically better off (instead of the same or worse off) than her natal family at the time of marriage. Finally, we consider an indicator for whether a woman's marital and natal households are in the same village to evaluate the geographical location of marital matches.

In Table 1, we present descriptive statistics for our outcome variables prior to the earthquake in 2001. In the pre-earthquake era, women appear to marry at an older age and men at a younger age in the affected districts in comparison to the unaffected districts. Women are more likely to marry a husband with a similar or a higher level of education in affected districts than in unaffected districts. In affected districts, 90 per cent of marriages are intra-caste vis-à-vis 97 per cent in the unaffected districts. Women in affected districts are more likely to marry into economically better-off households than their counterparts in unaffected districts. We also see no difference in the proportion of intra-village matches (about 10 per cent) between affected and unaffected districts.

A few limitations of this study are worth noting. First, our analysis is restricted to districts that were surveyed by the IHDS: it omits five less affected and three unaffected districts in Gujarat. Second, we are unable to control for women's natal family history as this information is unavailable from the IHDS.[4] Last, we only estimate the marriage market effects for those who survived the disaster and not the entire population exposed to the disaster, which would need to adjust for mortality and fertility effects.

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[2] As mentioned earlier, we identify affected (severely and less affected) districts based on Lahiri et al. (2001).

[3] Our results hold when we expand our choice of control states to include Madhya Pradesh and Rajasthan, two other neighbouring states of Gujarat. Our results are also robust to dropping the states of Madhya Pradesh, Rajasthan, and Maharashtra one at a time from the control group (results upon request).

[4] The IHDS is unique in recording not just the age and education of couples but also other characteristics of the marital match, such as socioeconomic status and location, that are not captured in other surveys.

5 Empirical strategy

The main objective of this study is to analyse the effects of a natural disaster on the marriage market. We e two sources of variation in a DID framework to identify the impact of the 2001 Gujarat earthquake on marriage outcomes. The first source of variation is geographical: districts in Gujarat that were impacted by the earthquake (*Affected*) are compared to the remaining districts of Gujarat and districts in the neighbouring state of Maharashtra that were not affected by the earthquake (*Unaffected*). Second, we use variation in marriage cohorts of women: women who married after the earthquake (*Post*) versus those already married before the unexpected negative shock (*Pre*). The following equation summarizes our basic empirical strategy:

$$y_{idt} = \alpha_0 + \alpha_1(Affected_d \times Post_t) + \boldsymbol{X}_{id}\pi + \theta_d + \lambda_t + \varepsilon_{idt} \quad (1)$$

where y_{idt} is the marital outcome of woman *i* residing in district *d* who got married in year *t; Affected*$_d$ is an indicator variable for whether the earthquake impacted district *d* or not; and *Post*$_t$ is a dummy variable that equals one for marriages between 2001 and 2005 and equals zero for marriages between 1996 and 2000. The coefficient of interest is α_1, which gives the differential impact of the earthquake in the affected districts compared to the unaffected districts. $\boldsymbol{X}_{id}$ is a vector of controls and includes years of a woman's education, caste indicators, dummies for urban location of the household and Hindu religion, and the number of male and female siblings the woman's spouse has.[5] The district of residence dummies (θ_d) control for time-invariant district-level factors that can influence marriage outcomes such as socioeconomic factors and local traditions. Marriage-year dummies (λ_t) control for factors that vary over time but are common across affected and unaffected districts. Standard errors are clustered at the district level and regressions are estimated using sampling weights.

The above analysis estimates the net effect of the earthquake on marriage outcomes. However, the negative shock of a natural disaster can affect families differently based on the earthquake's intensity in their area of residence. For example, households in districts with extreme devastation may suffer more economic losses or casualties in their families, thereby finding it harder to recover than those residing in areas of less destruction and damage. We rely on the severity information presented in Lahiri et al. (2001), who use casualties' data, shown in Figure 1, and modify equation (1) to incorporate this heterogeneity in impact.[6] The revised regression equation that we estimate is:

$$y_{idt} = \beta_0 + \beta_1(SeverelyAffected_d \times Post_t) + \beta_2(LessAffected_d \times Post_t) + \boldsymbol{X}_{id}\pi' + \theta'_d + \lambda'_t + \varepsilon'_{idt} \quad (2)$$

where *SeverelyAffected*$_d$ equals one for the districts in Gujarat most affected by the earthquake and *LessAffected*$_d$ is an indicator for the less severely impacted districts by the earthquake. The

[5] Caste is divided into four categories: General, Scheduled Caste (SC), Scheduled Tribe (ST), and Other Backward Class (OBC), the last three of which are historically disadvantaged caste groups in India as they lie at the bottom of the caste hierarchy. We include information about the husband's siblings (sex composition and number) to control for the type of bride the husband's family sought out. For example, if the husband has a younger female sibling, his family could ask for higher dowry payments to use it for his sibling's wedding. Appendix Table A1 presents the summary statistics for all pre-earthquake control variables for affected and unaffected districts.

[6] We also rank districts based on the destruction of housing stock due to the earthquake. Using the information in Eidinger (2001), we calculate the total number of houses that were destroyed or damaged and then rank the districts in descending order from the highest amount of destruction to the lowest. The destruction rankings match with the casualties-based approach.

comparison group comprises the unaffected districts in Gujarat and the state of Maharashtra. Thus, β_1 gives the DID impact of the earthquake on severely affected districts, while β_2 gives the differential impact on less affected districts. As before, $\boldsymbol{X}_{id}$ is a set of controls, and we include district of residence and year of marriage dummies.

Before discussing the results, we elaborate on two potential concerns with the identification strategy and argue for its validity.

Change in probability of marriage

The earthquake could affect the probability of marriage if, for example, negative health consequences render an individual unsuitable for marriage. This would make the $Post_t$ variable endogenous in our regression specifications. However, as noted earlier, marriage is nearly universal in India and non-marriage rates are negligible. We verify that this is indeed the case for Gujarat using census data from 2001 and 2011. Thus, it is reasonable to deduce that the earthquake only affected the timing of marriage and marital sorting, and that all men and women eventually get married. Our empirical strategy remains valid under this assumption.

Migration

As the IHDS does not include information on district of prior residence, we assume that the district of current residence is the district of residence at the time of the marriage decision and at the time of the earthquake. This assumption could be problematic if migration rates are high—adult men may migrate in search of better labour market or educational opportunities and women migrate post marriage due to patrilocality norms. It could also be the case that individuals use migration as a strategy to cope with the impact of the earthquake. However, we think that the possibility of migration posing a threat to our identification strategy is small given the internal migration profile in India. First, short-distance (intra-district followed by inter-district) migrants constitute a significant share of all internal migrants (Rajan and Bhagat 2021). Second, as mentioned earlier, about three-quarters of marriages in India are within the same district (Chiplunkar and Weaver 2021). Third, migration out of one's state is uncommon. Language barriers are one reason for this. Other reasons are the non-portability of government welfare schemes and state domicile requirement of government jobs (Rajan and Bhagat 2021). Finally, male migration rates in India are very low compared to other developing countries. This low level of mobility is due to the lack of a formal insurance system that would help migrants hedge the risks of migration costs coupled with relatively well-functioning rural informal insurance mechanisms (Munshi and Rosenzweig 2016). Nevertheless, we conduct tests to check the robustness of our results to migration, which we elaborate on in the next section.

6 Results

6.1 Effects on marriage outcomes

Table 2 presents the DID estimates of the effect of the Gujarat earthquake on marriage outcomes using equation (1). Columns (1) and (2) provide the effect on age at marriage for women and men, respectively. While statistically insignificant, the direction of the estimates indicate an expedited entry into marriage for both women and men. We do not find any statistically significant impact of the earthquake on educational sorting (column (3)). The earthquake also has no statistically significant impact on the probability of intra-caste marriages (column (4)) or the probability of out-of-village marriages (column (6)). In column (5), the point estimate indicates a 10-percentage point

decrease in the likelihood of women marrying into households that are relatively richer. The counterfactual average is 19 per cent.

These results may mask the nuanced effects of the disaster as the estimation assumes a homogenous impact across the affected areas. Therefore, we turn to our next set of results from equation (2), which incorporates severity information as calculated by Lahiri et al. (2001). The first two rows in Table 3 give the differential impact of the earthquake on severely affected and less affected districts, respectively, relative to the unaffected districts. In columns (1) and (2), we find that women's and men's ages at marriage statistically significantly decrease by an average of about 11 months (0.92 years and 0.91 years, respectively) in severely affected districts. The counterfactual average age at marriage is 19 years for women and 24 years for men. As in Table 2, we continue to find a statistically insignificant impact of the earthquake on educational sorting (column (3)), the probability of within-caste marriages (column (4)), and the probability of out-of-village marriages (column (6)). In column (5), we find that the earthquake lowered the probability of women marrying into better-off households in severely and less affected districts by about 10 percentage points, although only the point estimate on less affected districts is statistically significant.

6.2 Parallel trends analysis

Our DID model is identified if the parallel trend assumption holds that the marital outcome variables would have followed the same trends in the affected and unaffected districts in the absence of the earthquake. We test this in two ways. First, we estimate an event study or a dynamic model with leads and lags from the earthquake year by using an equation similar to equation (1). We focus on the same time periods as in equation (1), but instead of a *Post* dummy, we include separate interactions for each year of marriage with districts affected by the earthquake. We drop the year 2000 (the year before the earthquake) from the estimation equation to avoid perfect multicollinearity so that the coefficient for the year 2000 is zero by construction. The event study graphs for each outcome variable are presented in Appendix Figure A1. As the coefficients on the years in the pre-earthquake era are statistically insignificant (at the 95 per cent level of confidence), we conclude that the parallel trends assumption is likely not violated.

Next, we conduct a falsification test. We first restrict the sample to years of marriage in the pre-earthquake era (between 1996 and 2000) and falsely assume that the earthquake occurred in 1998. We then use equations (1) and (2) to test for any differential impacts on the marital outcome variables in affected districts due to this placebo treatment. Appendix Table A2 presents the coefficients from these regressions. These estimates are all statistically insignificant, which again leads us to infer that parallel trends are not violated in these data.

6.3 Robustness checks

We perform a few tests to ensure the robustness of our results. First, our results may be driven by the district of Kutch, which experienced the greatest devastation and highest number of casualties. Therefore, we drop the district of Kutch and re-estimate equations (1) and (2). The results from this exercise are presented in Panel A of Appendix Table A3. Reassuringly, these results are similar to those presented for the full sample in Tables 2 and 3.

Next, as mentioned in the previous section, we conduct two tests to ensure that migration does not threaten the validity of our identification strategy and affect our results. As most migration in India is intra-state, we drop the only unaffected district in Gujarat from our sample to ensure that all earthquake-affected districts lie in Gujarat and all earthquake-unaffected districts lie in

Maharashtra in our study sample. From Panel B of Appendix Table A3, we find that the results are invariant to this restriction.

Finally, we use two statistics about migration in India to test the robustness of our results to the possibility of migration. The first is that women migrate post marriage, but three-quarters of all marriages are within the same district (Chiplunkar and Weaver 2021). The second is that male migration within rural areas is extremely low (Munshi and Rosenzweig 2016). Given this, we restrict our sample to rural households, a low migration probability sample, and re-estimate regressions. These estimates, presented in Panel C of Appendix Table A3, continue to have a similar statistical significance and sign to our main results.[7]

7 Mechanisms

Our results indicate that the earthquake expedited age at marriage for women and men and decreased the likelihood of women marrying into relatively richer households. In this section, we discuss the mechanism underlying our findings and provide suggestive evidence to rule out alternative mechanisms.

7.1 Dowry expenditures

Although illegal under the Dowry Prohibition Act of 1961, over 85 per cent of marriages in India include dowry payments, often amounting to several years of a household's annual income (Anderson 2007a; Chiplunkar and Weaver 2021).[8] Many parents start accumulating wealth for dowry payments early to meet social expectations and demands, sometimes right after their daughter is born (Anukriti et al. 2022). Here, we examine whether changes to dowry expenditures can explain the decrease in the age of women at marriage we find after the earthquake.

As we do not have data on actual payments made by the brides' families at the time of their marriage, we use a survey question to elicit indirect dowry information. Specifically, the IHDS asks eligible women: 'In your community, for a family like yours, at the time of marriage, how much money is usually spent by the boys' and girls' family?'. Following the literature, we consider two measures: gross wedding expenditure, which is the average expenditure amount (in INR10,000) by the girls' family; and net wedding expenditure, which is the difference between the average expenditure by girls' family and by boys' family (also in INR10,000).[9] We think these measures serve as reasonable proxies as an individual's response will likely be driven by their own wedding (and hence dowry) experience.

[7] One additional finding from Panels A and C of Appendix Table A3 is a statistically significant decrease in the probability of intra-village marriages in severely affected districts.

[8] The Dowry Prohibition Act was not successful in preventing dowry payments or punishing dowry offenders (Dalmia and Lawrence 2005). Aside from weak enforcement, the act of gift-giving also affords a legal loophole in the Act (Caplan 1984).

[9] Using data from the 2006 Rural Economic and Demographic Survey, we find that, between the years of 2000 and 2002, net dowry payments (defined as gross payments by the bride's family minus gross payments made by the groom's family) in Gujarat averaged INR22,826 (approximately US$300) and the average gross payments made by the bride to the groom or his family was INR38,835 (approximately US$500). As the sample size is very small, we do not use this data for our analysis.

As our results are driven by the severely affected districts, we examine the relationship between marriage age and dowry payments while accounting for the severity of the earthquake. Our regression specification is given as:

$$WeddingExp_{idt} = \beta_0' + \beta_1'(MarriageAge_{id} \times SeverelyAffected_d \times Post_t) + \beta_2'(MarriageAge_{id} \times LessAffected_d \times Post_t) + \beta_3'(SeverelyAffected_d \times Post_t) + \beta_4'(LessAffected_d \times Post_t) + \beta_5'(SeverlyAffected_d \times MarriageAge_{id}) + \beta_6'(LessAffected_d \times MarriageAge_{id}) + \beta_7'(MarriageAge_{id} \times Post_t) + \beta_8'(MarriageAge_{id}) + \boldsymbol{X}_{id}\pi''' + \theta_d''' + \lambda_t''' + \varepsilon_{idt}''' \quad (3)$$

where $WeddingExp_{idt}$ is the gross or net wedding expenditure (in INR10,000) reported by woman *i* residing in district *d* who got married in year *t*; $MarriageAge_{id}$ specifies the woman's age at marriage; $SeverelyAffected_{ds}$ equals one for the districts in Gujarat that were severely affected; and $LessAffected_{ds}$ indicates districts that were less severely impacted by the earthquake. $Post_t$ is an indicator for whether a woman got married in the five years after the earthquake. We include district dummies (θ_d), marriage-year dummies (λ_t), and the same set of control variables $\boldsymbol{X}_{id}$ as in equation (2). In this equation, the coefficient β_1' gives us the differential effect on wedding expenditures by age at marriage in severely affected districts after the earthquake and β_2' provides the same for less affected districts.

Table 4 presents the results from estimating equation (3). Looking at the full sample (columns (1) and (2)), we find no significant impact of the earthquake on a woman's age at marriage on dowry payments. Anukriti et al. (2022) report that most Indian marriages involve a net positive dowry to the groom's family, i.e., the bride's family usually pays significantly more than the groom's family. They find evidence that the proportion of marriages with a greater payment on the part of the groom's family is very small. Given this information, we also focus on the subsample where net wedding expenditure is greater or equal to zero (columns (3) and (4)). We now find a statistically significantly positive coefficient on *Post*×*SeverlyAffected*×*MarriageAge*. The point estimates suggest that for each additional year of delay in a woman's marriage, the net (gross) wedding expenditure increases by INR3,200 (6,400) in severely affected districts after the earthquake. Put differently, marrying off a woman early in these districts could result in her natal family saving on wedding-related expenditures by these same amounts.

The estimates above suggest that, when faced with the negative shock of the earthquake, parents marry off their daughters early to save on dowry and wedding expenditures and smooth their consumption.[10] It could also be the case that simple, inexpensive weddings are more likely to be socially condoned during challenging economic times (Pincha 2016) and parents with insufficient savings take this opportunity to marry off their daughters early with modest wedding expenses. In their quest to marry their daughters early, parents may not be able to attract the best-quality matches, which could also explain why we find a lower probability of women marrying into relatively wealthier households.

[10] The use of dowries for consumption smoothing is also postulated by Khanna and Kochar (2019), who find that age at marriage decreased following a flood in India. In contrast, Corno et al. (2020) find that marriages get delayed because parents struggle to afford dowry payments following negative income shocks due to droughts.

7.2 Alternative mechanisms

Marriage squeeze effects

Casualties from the disaster could distort the marriage market sex ratios and lead to a mismatch in the number of potential brides or grooms, resulting in a marriage squeeze. This could be mitigated by changes in the age profile of spouses or in the prevalence and amount of dowry (Anderson 2007b; Caldwell et al. 1983; Rao 1993).

While we do observe a reduction in women's and men's ages at marriage, our findings are unlikely to be explained by marriage squeeze effects. We use two sources of data to corroborate this statement. First, we rely on Lahiri et al. (2001), who use data from the 1991 census to estimate casualty figures by age and gender. While approximately 55 per cent of the casualties are between 15 and 59 years of age, the gender distribution reveals that 51 per cent of the deceased within this age group were male. When the fatality data is broken down by district, the numbers of male and female deaths are found to be roughly the same in each affected district. Second, we use 1991 and 2001 census data to calculate the state-wide sex ratio (of the living) in the 15−49 age group. We find the gender breakdown to be approximately 52 per cent males to 48 per cent females in that age group in both census years, indicating the lack of a substantial change in the sex ratio over the decade.[11] Thus, the marriage squeeze effects of the earthquake are likely trivial.

Earthquake's effect on education

If schooling infrastructure was destroyed in the earthquake, investments in education would likely have decreased, which could expedite entry into marriage. Indeed, surveys in the aftermath of the earthquake document extensive infrastructure damage: 9,000 primary school buildings were completely damaged or destroyed (Mishra 2004). One way to test whether education affected the age at marriage is to check the gap between the year the individual entered into marriage and the year they ended their investment in education. For marriages taking place in the post-earthquake era, we find that less than 3.5 per cent of women and less than 0.5 per cent of men attended an educational institution in the five years leading up to their wedding. This suggests a negligible impact of the earthquake on the educational investment of individuals in our analysis.

Marriage search costs

The earthquake may have restricted the scope of the marriage search. Alternatively, parents may have tried to expand their search for prospective mates for their children to provide them with greater insurance against the negative economic consequences of the disaster, resulting in increased marriage search costs. This would have increased the age at marriage as parents spent more time searching for a suitable spouse for their children. In contrast, our findings document an expedited entry into marriage for both men and women—thus the role of marriage search costs in explaining our results is likely inconsequential.

[11] While Lahiri et al. (2001) look at the death toll for the ages 15–59, the 1991 and 2001 census data allow us to calculate only the 15–49 age group data.

8 Conclusion

Natural disasters are severe and unexpected adverse events that entail economic losses in addition to loss of life and property. In this paper, we examined the impact of the 2001 Gujarat earthquake on marriage outcomes. We found that the earthquake reduced age at marriage for men and women and decreased the likelihood of women marrying into wealthier households. However, there was no impact on matching by educational status or in the likelihood of intra-caste and out-of-village marriages. We hypothesized that the negative shock from the earthquake led parents to expedite their daughter's marriage to save on dowry expenditures and we confirmed this using a proxy for dowry payments.

These results are noteworthy as marital matches have long-term consequences, especially in a setting where divorce is an anomaly. Early marriage, for instance, is associated with reduced women's education and labour force participation, worse maternal and child health, low autonomy of women within households, and greater likelihood of domestic violence (Chari et al. 2017; Field and Ambrus 2008; Jensen and Thornton 2003). Marital sorting by parental background, on the other hand, has implications for the intergenerational transmission of socioeconomic conditions (Charles et al. 2013).

Overall, our results show that marriage market responses can be quite substantial in the aftermath of a natural disaster. Given how this institution can induce long-lasting demographic changes, policy makers would do well to account for these changes when formulating comprehensive disaster management policies.

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Tables and figures

Table 1: Marriage outcome variables before the earthquake

Variable	Affected districts			Unaffected districts			t-stat for mean diff
	Mean	SD	N	Mean	SD	N	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Woman's age at marriage	18.85	2.99	273	18.15	2.80	471	−3.17
Spouse's age at marriage	23.07	3.66	273	23.50	3.67	471	1.55
Spouse more/equally educated	0.85	0.35	273	0.76	0.43	471	−3.28
Spouse from same caste	0.90	0.29	273	0.97	0.16	471	3.63
Spouse's family better off	0.26	0.44	273	0.17	0.38	471	−2.95
Spouse from same village	0.10	0.30	273	0.11	0.31	469	0.52

Source: authors' calculations using India Human Development Survey-I (2004–05) data.

Table 2: Effect of the earthquake on marriage market outcomes

	Woman's age at marriage	Spouse's age at marriage	Spouse more/equally educated	Spouse from same caste	Spouse's family better off	Spouse from same village
	(1)	(2)	(3)	(4)	(5)	(6)
Post×Affected	−0.32	−0.47	−0.03	−0.01	−0.10**	−0.02
	(0.46)	(0.49)	(0.05)	(0.04)	(0.05)	(0.04)
Control mean	19.12	23.98	0.78	0.97	0.19	0.12
Observations	1,277	1,277	1,277	1,276	1,277	1,271
R^2	0.31	0.26	0.16	0.13	0.12	0.13

Note: ** denotes significance at the 5% level. Robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of marriage fixed effects. Columns (1) and (2) present results on women's and their spouse's age at marriage. In columns (3) to (6), we present results on the quality of marital unions by specifically looking at educational hypergamy, caste homogamy, differences in economic status between the bride's and groom's family, and the geographic location of the union.

Source: authors' calculations using India Human Development Survey-I (2004–05) data.

Table 3: Effect by severity of earthquake

	Woman's age at marriage	Spouse's age at marriage	Spouse more/equally educated	Spouse from same caste	Spouse's family better off	Spouse from same village
	(1)	(2)	(3)	(4)	(5)	(6)
Post×SeverelyAffected	−0.92**	−0.91**	−0.04	−0.02	−0.11	−0.06
	(0.41)	(0.43)	(0.10)	(0.07)	(0.07)	(0.04)
Post×LessAffected	0.11	−0.15	−0.01	0.00	−0.10*	0.00
	(0.63)	(0.68)	(0.06)	(0.04)	(0.06)	(0.04)
Control mean	19.12	23.98	0.78	0.97	0.19	0.12
N	1,277	1,277	1,277	1,276	1,277	1,271
R^2	0.32	0.26	0.16	0.13	0.12	0.13

Note: ** and * denote significance at 5% and 10% level, respectively. Robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of marriage fixed effects. Severity of earthquake information comes from Lahiri et al. (2001). Columns (1) and (2) present results on women's and their spouse's age at marriage. In columns (3) to (6), we present results on the quality of marital unions by specifically looking at educational hypergamy, caste homogamy, differences in economic status between the bride's and groom's family, and the geographic location of the union.

Source: authors' calculations using India Human Development Survey-I (2004–05) data.

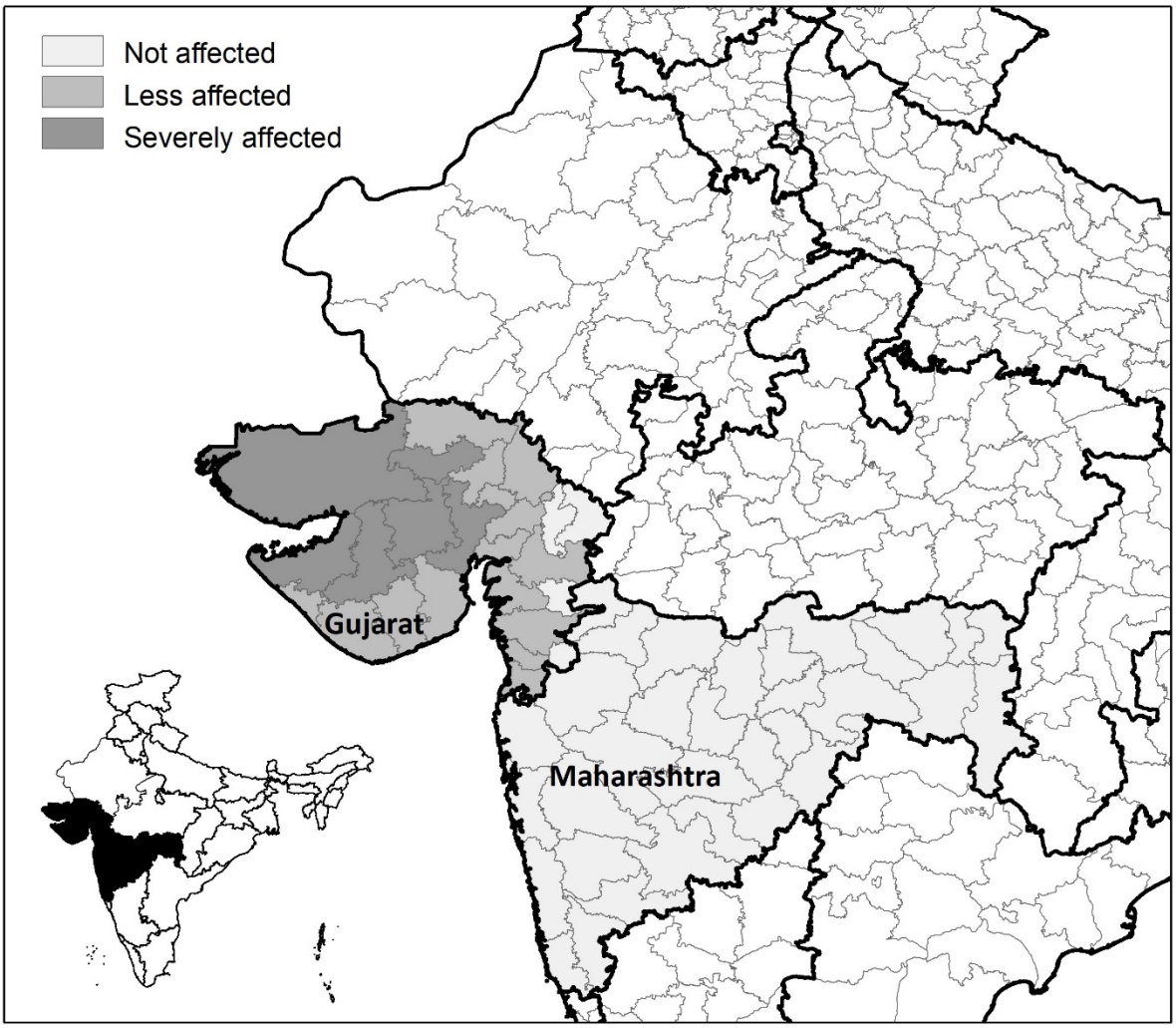
Table 4: Effect on proxy for dowry payments

	Full sample		Net expenditure ≥ 0	
	Net	Gross	Net	Gross
	(1)	(2)	(3)	(4)
Post×SeverelyAffected×MarriageAge	0.24	−0.09	0.32**	0.64***
	(0.22)	(0.39)	(0.16)	(0.18)
Post×LessAffected×MarriageAge	0.08	−0.10	0.02	−0.25
	(0.11)	(0.27)	(0.15)	(0.32)
Control Mean	1.59	7.20	2.20	7.90
N	1,259	1,259	1,019	1,019
R^2	0.10	0.34	0.22	0.36

Note: *** and ** denote significance at 1% and 5% level, respectively. Robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of marriage fixed effects. Gross expenditure is the average amount spent by the bride's family (in INR10,000) and net expenditure is the difference between the average expenditures of the bride's and the groom's family. Odd-numbered columns present results for net wedding expenditure and even-numbered columns present results for gross wedding expenditure (also in INR10,000).

Source: authors' calculations using India Human Development Survey-I (2004–05) data.

Figure 1: Map showing *affected* and *unaffected* districts



Note: based on information from Lahiri et al. (2001).

Source: this map was created using ArcGIS (version 10.3). GIS shapefiles were downloaded from https://international.ipums.org/international/.

Appendix

Table A1: Control variables for marriages pre-earthquake

Variable	Affected districts			Unaffected districts			t-stat for mean diff
	Mean	SD	N	Mean	SD	N	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Education of woman (years)	6.81	5.16	273	7.34	4.20	471	1.46
Urban	0.54	0.50	273	0.37	0.48	471	−4.66
Hindu	0.86	0.34	273	0.88	0.33	471	0.48
General caste	0.44	0.50	273	0.42	0.49	471	−0.72
Scheduled caste (SC)	0.10	0.29	273	0.14	0.34	471	1.71
Scheduled tribe (ST)	0.05	0.22	273	0.10	0.31	471	2.72
Other backward classes (OBC)	0.41	0.49	273	0.34	0.48	471	−1.79
Number of husband's sisters	1.73	1.29	273	1.59	1.31	471	−1.41
Number of husband's brothers	1.74	1.26	273	1.64	1.25	471	−1.01

Source: authors' calculations using India Human Development Survey-I (2004–05) data.

Table A2: Falsification test

	Woman's age at marriage	Spouse's age at marriage	Spouse more/equally educated	Spouse from same caste	Spouse's family better off	Spouse from same village
	(1)	(2)	(3)	(4)	(5)	(6)
Post_98×Affected	−0.26	−0.15	−0.01	−0.03	−0.04	0.07
	(0.34)	(0.45)	(0.06)	(0.04)	(0.07)	(0.05)
Post_98×SeverelyAffected	−0.21	−0.16	0.05	0.02	−0.07	0.08
	(0.39)	(0.56)	(0.06)	(0.05)	(0.08)	(0.05)
Post_98×LessAffected	−0.30	−0.14	−0.05	−0.06	−0.02	0.06
	(0.35)	(0.49)	(0.05)	(0.05)	(0.08)	(0.08)
N	744	744	744	744	744	742

Note: robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of marriage fixed effects. Here we limit our sample to pre-earthquake years (1996–2000) and falsely assume that the earthquake occurred in 1998. The first row estimates the coefficient based on equation (1) and the second and third rows present the coefficients from estimating equation (2).

Source: authors' calculations using India Human Development Survey-I (2004–05) data.

Table A3: Robustness checks

	Woman's age at marriage	Spouse's age at marriage	Spouse more/equally educated	Spouse from same caste	Spouse's family better off	Spouse from same village
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: Dropping district of Kutch			
Post×Affected	−0.36	−0.53	−0.03	−0.01	−0.12***	−0.03
	(0.47)	(0.50)	(0.05)	(0.04)	(0.04)	(0.04)
Post×SeverelyAffected	−1.08***	−1.10***	−0.06	−0.04	−0.17***	−0.08*
	(0.37)	(0.38)	(0.07)	(0.07)	(0.05)	(0.04)
Post×LessAffected	0.11	−0.15	−0.01	0.00	−0.10*	0.01
	(0.63)	(0.68)	(0.07)	(0.04)	(0.06)	(0.04)
			Panel B: Dropping unaffected district in Gujarat			
Post×Affected	−0.28	−0.48	−0.02	−0.01	−0.84*	−0.03
	(0.46)	(0.50)	(0.05)	(0.04)	(0.05)	(0.04)
Post×SeverelyAffected	−0.90**	−0.88**	−0.04	−0.02	−0.10	−0.06
	(0.41)	(0.43)	(0.07)	(0.07)	(0.07)	(0.04)
Post×LessAffected	0.17	−0.18	0.00	0.01	−0.07	0.00
	(0.62)	(0.72)	(0.06)	(0.04)	(0.05)	(0.03)
			Panel C: Rural households			
Post×Affected	−0.34	−0.92	−0.00	−0.01	−0.07	−0.08**
	(0.54)	(0.77)	(0.07)	(0.05)	(0.08)	(0.04)
Post×SeverelyAffected	−1.11**	−1.37**	−0.04	−0.05	−0.06	−0.03
	(0.45)	(0.60)	(0.10)	(0.08)	(0.12)	(0.04)
Post×LessAffected	0.21	−0.60	0.02	0.028	−0.08	−0.11**
	(0.83)	(1.19)	(0.09)	(0.06)	(0.08)	(0.04)

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively. Robust-clustered standard errors at the district level are reported in parentheses. Regressions include all controls and district and year of marriage fixed effects. Panel A presents results for the estimation without the district of Kutch, Panel B by removing the only unaffected district in Gujarat in our data, and Panel C by considering only rural households. Within each panel, the first row estimates the coefficient based on equation (1) and the second and third rows present the coefficients from estimating equation (2).

Source: authors' calculations using India Human Development Survey-I (2004–05) data.

Figure A1: Difference-in-difference event study

(a)

(b)

(c)

(d)

(e)

(f)

Note: the estimated coefficient and the 95% confidence interval are shown.

Source: authors' calculations using India Human Development Survey-I (2004–05) data.