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Abstract

Purpose – The purpose of this paper is to identify the effects earthquakes may have on rates of marriage and divorce in China, a country strongly affected by losses due to earthquakes.

Design/methodology/approach – This paper studies the effect of earthquakes on marriage and divorce rates in China between 2000 and 2011, using panel data from 31 provinces as well as from Sichuan at the prefecture level, a province that has a high frequency of earthquakes.

Findings – The results show that when controlling for demographic, economic, and social factors, losses due to earthquakes are found to be associated with increases in both marriage and divorce rates. While the estimated elasticities are low, amounting to 1.92×10^{-2} and 6.102×10^{-2}, respectively, they are highly significant, suggesting that a doubling of losses due to earthquakes increases marriages by 1.92 percent and divorces by 6.102 percent with a lag of one year. Since the first elasticity is smaller than the second, losses due to earthquakes may influence familial instability. Moreover, these effects increase in the second year but cannot be traced beyond three years after the disaster.

Originality/value – In view of the cost imposed on society by instable family relationships, these findings point to a need to provide relief to families after earthquake disasters.

Keywords Divorce rate, Earthquake disaster, Earthquake losses, Marriage rate

Paper type Research paper

1. Introduction

In recent years earthquakes have occurred relatively frequently in China, causing tremendous losses for the affected local economies. According to statistics from the China Earthquake Administration, between 1900 and 2011 earthquakes affected 69.06 mn people, killed 875,000, and caused direct economic losses of as much as US$95.1 bn. The majority of scholars studying earthquakes have been focussing on direct economic effects (Raddatz, 2007; Noy, 2009; Xu and Mo, 2013) whereas social effects of earthquakes have been neglected. Particularly in China, a country facing a demographic turning point (Cai, 2010; Liu, 2011), the future quality of children is decisive for economic development. With child achievements suffering from the breakup of families, preserving their stability in spite of disruptions caused by earthquakes is important for promoting future economic growth and relieving social tensions (Su and Zhang, 2008; Fu and Li, 2008). Therefore, while the direct economic effects of earthquake disasters are temporary, their indirect effects through marriage and divorce may be longer lasting and potentially more important.

After the "5.12" Sichuan earthquake[1] of May 12, 2008, divorce rates in Sichuan started rising gradually, and have since been continuously higher than in the rest of the country. Measured relative to the resident population, they rose from 2.05 to 2.88 percent from 2007 to 2011. This caused sociologists to hypothesize earthquakes' impact on divorces. Although there are many social factors driving marriage and divorce rates such

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as changing values, the simplification of divorce procedures, and improved material conditions of divorced wives, this rapid and particular increase of divorce rate in Sichuan is likely to reflect deep socio-psychological impacts of earthquake.

Natural hazards are known to have such impacts, which can be detailed as follows (Reijneveld *et al.*, 2003; Ahern *et al.*, 2005; Chae *et al.*, 2005). First, a sudden adverse incident can lead to post-traumatic stress disorder (PTSD), i.e., a lasting mental disorder caused by witnessing death or experiencing the risk of death. It mainly manifests itself as a tendency to withdraw oneself, being overly on guard, and reliving the trauma, thus undermining communication between husband and wife (Neria *et al.*, 2008). Second, disasters change people's perception of value, self and philosophy of life, leading them to re-examine especially their close interpersonal relationships (Cohan and Cole, 2002). Married couples in unharmonious relationships may become conscious of the fragile and precious nature of life, tending to break up in order to look for new happiness. Third, disasters can become "touchstones" of people's feelings. According to a report on Fuji Television, the big "3.11" tsunami hitting Fukushima and its nuclear power plant on March 11, 2011, which the Japanese saw as the calamity of the century, had a profoundly destabilizing effect on people's views of marriage, especially among Japan's younger generation. There was a 20-30 percent increase in the number of people seeking divorce counseling after the tsunami. In addition, a survey reported in the weekly magazine *AERA* (published by Asahi Shimbun) showed that 15 percent of Japanese housewives "considered divorce after the earthquake". The complaint most often cited was, "The husband abandoned wife and children at the time of the earthquake and escaped". In some cases, the sudden occurrence of the earthquake also revealed extramarital affairs.

The hypothesis that earthquakes bring about higher divorce rates has been challenged by Zeng *et al.* (1993), who point out that there was no significant change in the divorce rates in Hebei after the big 1976 Tangshan earthquake. However, the social environment and people's values have undergone tremendous change since then. Especially when it comes to views on divorce, there are stark differences between the two periods, arguing against a simple comparison between the Tangshan and Sichuan earthquakes.

Moreover, the exclusive focus on divorce is unwarranted. Earthquakes may have an impact also on marriage and the number of children. On the one hand, they may get people to renounce to marriage because they deem economic prospects too unfavorable. On the other hand, earthquakes might make people appreciate mutual support in adversity, motivating them to marry or to renounce to a planned divorce. Finally, there is an ambiguous effect on the number of children as well. Disasters may shatter social norms because survivors concentrate on the "here and now", with more children born (often out of wedlock) as a consequence. The more important response, however, is for couples to renounce to children (or additional ones) because they consider economic prospects after the disaster too unfavorable.

In view of Chinese emphasis on the quality rather than the quantity of children, the present study neglects the possible impact of earthquakes on the number of children. Rather, it focusses on earthquakes and losses caused by them as one of the determinants of marriage and divorce. Its main finding is that with a lag of up to two years, losses are associated with an increase in both, with the effect on divorce dominating. It is based on Chinese provincial panel data covering the years 2000 and 2011 as well as prefecture-level data from Sichuan province, which has a high frequency of earthquakes.

The rest of this paper is structured as follows. Section 2 contains a review of the literature. Section 3 provides a descriptive analysis of the data used in the empirical study performed in Section 4. The final Section 5 offers conclusions and suggestions for policy.

2. Review of the literature

2.1 General demographic effects of natural hazards or adverse external shocks

One of the early studies suggesting that natural hazards might affect demography is the one by Fukuda *et al.* (1996), revolving about the impact of the Hanshin earthquake in Japan on the activity of sperm in males. Fukuda *et al.* find a decrease in sperm in samples from places where the magnitude of the earthquake had been above six. Moreover, the higher the economic loss experienced by the patient, the slower was the return to a normal activity level. The likely cause is psychological strain and trauma affecting sperm activity and ultimately birth rates. Furthermore, Fukuda *et al.* (1998) establish that after the 1995 Hanshin earthquake there was a decrease in the number of births accompanied by a lowered proportion of male infants born.

There are also studies of population mortality following earthquakes. Armenian *et al.* (1998) find that the losses suffered due to the 1988 earthquake in Soviet Armenia were associated with an increased likelihood of acquiring cardiovascular and heart disease as well as a higher mortality rate later in life. Studying the 1999 earthquake in Taiwan, Chan *et al.* (2003) find the number of casualties among females and elderly to be above average, whereas the mortality rates of people in all age brackets declined after the event – a puzzling combination.

In terms of marital decisions, there are several branches of literature on impact of natural hazards or adverse external shocks on behaviors and decisions of people.

Research on stress and economic circumstances tend to believe that natural hazards invite increase of divorce rate. PTSD (Neria *et al.*, 2008) and environmental stress may lead to poor marital interaction, satisfaction, and relationship functioning (Story and Bradbury, 2004). According to Oppenheimer (1988) and White and Rogers (2000), marital decisions are related to economic factors that influence the operation of a household, such as real wages, employment opportunities, and overall economic environments. South (1985) and Yeung and Hofferth (1998) have proved that negative economic environments are accompanied with breakdown of relationships.

In terms of marriage rate, research on stress, and economic circumstances summarized above (Oppenheimer, 1988; White and Rogers, 2000; Story and Bradbury, 2004) suggests marriages decline after a disaster. However, there are many different voices. Attachment theory in Bowlby (1969) concludes that life-threatening events lead to affiliation responses, suggesting that dating couples are more likely to get married after natural hazards. Theoretical analysis of terror management in Solomon *et al.* (1991) states that existential fear of death and reminders of death people may increase people's incentives to engage themselves in romantic relationships in order to cope with stress from witnessing death and fear of death through social support. Cohan and Cole (2002) prove these theories by examined changes in marriage, birth, and divorce rates following Hurricane Hugo in 1989. Their time series analysis indicated that in the year following the hurricane, marriage, birth, and divorce rates increased in those 24 counties which were declared disaster areas compared to the 22 other counties that were not. From this, the authors proved that life-threatening events trigger decisions that have demographic consequences. Prati and Pietrantoni (2014) replicate work of Cohan and Cole (2002) but find results in the opposite direction. They admit that the direction of the marriage rate change may be in either direction and depends on the characteristics of the disaster and on social and economic conditions of the society.

We agree that impact of sudden external natural hazards on marital decisions may be negative as well as positive. There are many complicated factors behind the phenomenon. In the year when earthquakes actually happen, marriage and divorce rates may decrease in the affected areas because of the limitation from affected economic and personal physical conditions. While in the one to two years after the earthquakes, all the factors mentioned above (PTSD, environmental stress, change of perception of value, self and philosophy of life, failure to pass the "touchstones test" of married couples, and so on) may have an leading impact and result in an increase of divorce rate. Due to the incentives to involve in a romantic relationship to cope with stress through social support, marriage rates are also likely to increase. We use a more strict fixed effect model in China's context to analyze the impact of earthquakes on marriage and divorce rates, capturing both spatial differences and time differences.

2.2 Determinants of marriage and divorce rates

Determinants of marriage rates include not only genetic (Johnson *et al.*, 2004) but also societal factors such as education, spouse choice (Allendorf and Ghimire, 2013), and occupation (Gu, 1986). The economic situation also influences marriage decisions; in the case of China for instance, Shanghai saw a falling trend in marriage rates during the 1930s, a period of economic crisis (Lu, 2011).

As to divorce, there are several hypotheses.

First, there is a demographic explanation. A negative correlation between the male/female ratio in the population and the divorce rate has been observed in general, while in the USA, it is positive (Lester, 1999). As to China, the increased occurrence of divorce in China has also been related to variables such as age composition, education level, and population mobility (Zhang, 1997, 2008; Luo, 1999).

Second, some scholars emphasize socio-economic influences. For example, areas characterized by high work pressure have been found to have comparatively high rates of divorce (South, 1985). Over time, rates decline during recessions and rise when living conditions turn favorable again (Glick and Lin, 1986). A social environment characterized by similarity of values, harmonious social relations, and strong social bonds has a stabilizing effect on marital relations, resulting in fewer divorces (Breault and Kposowa, 1987). In the case of China in particular, several researchers have pointed to the country's social transformation which comprises changes in social hierarchy, relationships between the sexes, the rate of female participation in the labor market as well as loss of social cohesion. These influences may have contributed to the increase in Chinese divorce rates (Ye and Lin, 1998; Zhang, 2007; Fu and Li, 2008; Su and Zhang, 2008; Xia, 2008; Chen, 2009; Li and Yang, 2011).

Third, there is the economic explanation, which examines the costs and benefits associated with divorce compared to continued marriage. The recent past has seen a decrease in the cost of divorce in China, for instance, the facilitated process of divorce and more tolerated social environment for divorce, which encourages divorce. However, the development of markets in general and for labor in particular has substantially increased opportunities for contact with people of the opposite sex after marriage. Therefore, the cost of finding a replacement for the present spouse has been falling, while the benefits associated with continuing marriage do not seem to have changed much. Overall, the benefit-cost ratio may have shifted in favor of divorce (Ye, 1997; Xiang, 2011). Also, there is a hypothesis stating that changes in family law are determinants of divorce rates. Differences in divorce rates among the 50 American states can to a certain extent be attributed to differences in the implementation of

no-fault divorce laws (Nakonezny *et al.*, 1995). In China, the norms of family law are nationally uniform (except for special provisions regarding the legal marriage age for minorities). Still, their enforcement differs between regions and has been changing over time. Moreover, the subjective views of judges are of importance (Xu and Ye, 2002).

However, the Chinese studies cited are limited to qualitative analysis obviating an assessment of the relative importance of the factors determining rates of marriage and divorce. A first attempt at quantitative analysis was undertaken by Meng (2000), who used time series data to find divorce rates to be positively correlated with the share of people in non-agricultural sectors and the level of urbanization, without however analyzing the two simultaneously. Multiple regression was applied by Liu (2000) to analyze the relationship between divorce rates and several economic determinants. People's economic situation, their mobility, the development of the service sector (which implies employment for women, advanced consulting industry and enriched social interaction) as well as the educational level as an indicator of attitude toward marriage proved significant. Xu and Ye (2002) suggested five variables (including social cohesion and household composition) to explain regional variation in Chinese divorce rates. Social cohesion, an indicator mainly reflecting urbanization and mobility, is closely related to the explanatory variables used by Meng (2000) and Liu (2000). Household composition was important because the presence of children serves to stabilize marriage. Based on micro-level panel data from Chinese villages covering the years 2003-2009, Gao (2011) has identified the increasing number of migrant workers as a major factor leading to rising divorce rates in the countryside. Other factors such as the village's land resources, sex ratio, and the number of young children in the household also had a significant impact.

By studying the effect of earthquakes on marriage and divorce opposed to their direct economic effects, this paper contributes to the literature in the following ways. First, media and sociologists have advanced contradicting hypotheses concerning the effects of natural hazards on marriage and divorce. To the best knowledge of the authors, this is the first study testing these hypotheses, controlling for more economic and social factors than hitherto. Second, the existing literature on the effects of earthquakes mainly relies on single events, such as the great 1995 Hanshin earthquake (Fukuda *et al.*, 1996), the 1988 earthquake in the former Soviet Republic, Armenia (Armenian *et al.*, 1998), and the 1999 Taiwan earthquake (Chan *et al.*, 2003). By way of contrast, this paper uses data on all major earthquakes in China over a period of 13 years. Since some of these data are at the level of prefectures, improving chances of identifying the many factors influencing marriage and divorce compared to previous work. Third, by focussing on the longer-term social consequences of earthquakes, this work may offer recommendations to policy that go beyond immediate disaster relief.

3. Data sources and descriptive analysis

Data for demographic, economic, and social factors comes from the 1999-2011 *China Statistical Yearbook* as well as the statistical yearbooks of prefecture-level cities and autonomous prefectures. Rates of marriage and divorce are published in the *Database of China's Economic and Social Development Statistics* from 1999 to 2011. The source of the 1999-2007 data on earthquakes is the *China Earthquake Yearbook*[2], that of the 2008-2011 data, the *China Statistical Yearbook*.

3.1 Earthquakes disasters in China

Due to the vast area covered by China, provinces and directly administered municipalities are affected by earthquakes to varying degrees. Table I displays their

Province	Frequency of earthquakes	Total direct economic loss due to earthquakes (in mn. yuan)	Total number of injuries and deaths due to earthquakes
Beijing	0	0	0
Tianjin	0	0	0
Hebei	2	16.07	31
Shanxi	4	146.08	81
Inner Mongolia	6	1,148.00	1,134
Liaoning	2	115.01	14
Jilin	1	110.68	2
Heilongjiang	1	27.45	12
Shanghai	0	0	0
Jiangsu	0	0	0
Zhejiang	1	8.74	0
Anhui	1	232.35	0
Fujian	1	10.02	0
Jiangxi	1	2,037.59	788
Shandong	0	0	0
Henan	2	71.26	41
Hubei	2	6.03	1
Hunan	0	0	0
Guangdong	1	23.08	0
Guangxi	1	25.32	4
Hainan	1	30.68	0
Chongqing	4	128.35	47
Sichuan	15	857,690.34	446,347
Guizhou	1	0	14
Yunnan	35	33,877.94	6,716
Tibet	9	1,836.15	237
Shaanxi	1	13.02	1
Gansu	11	986.22	571
Qinghai	11	23,447.64	13,706
Ningxia	0	0	0
Xinjiang	31	3,671.08	5,213
Sum in total	145	925,659.11	474,960

Note: 1 yuan = US$0.1642 at 2015 exchange rates
Sources: *China Statistical Yearbook*; *China Earthquake Yearbook*

Table I.
Direct economic and human losses due to earthquakes in China, by province (1999-2011)

frequency, direct economic loss caused, and the number of casualties in each province between 1999 and 2011. It shows that earthquakes are centered in the central and western areas, i.e., Sichuan, Yunnan, Gansu, Qinghai, Xinjiang, and Tibet, where economic and human losses are also more serious than in other provinces.

3.2 Rate of marriage and divorce in prefecture-level cities and autonomous prefectures with a high frequency of earthquakes

Data from most areas in Gansu, Tibet, Xinjiang, and Yunnan is insufficient to form time series. However, Sichuan and Qinghai also belong to the provinces strongly affected by earthquakes (see Table I). There, rates of marriage and divorce of selected prefecture-level cities and autonomous prefectures are available for the years 2000 to 2011. In 12 out of 18 cases, marriage rates were higher in the year following the earthquake, and in nine out of 17 cases[3], divorce rates were also higher in the year after the earthquake (not shown). Hence, earthquakes tend to bring increase in both marriage and divorce rates, likely with a lag.

4. Empirical analysis

4.1 Basic model

Based on studies by Liu (2000), Xu and Ye (2002), Gao (2011), we construct a year-province panel data and the following specification is stipulated:

$$Y_{it} = \alpha' Z_{it} + \beta_1' X_{1it} + \beta_2' X_{2it} + \beta_3' X_{3it} + \varepsilon_{it} \quad (1)$$

where Y_{it} represents the rate of marriage (or divorce) of province i in year t. They are calculated relative to resident population, in keeping with Hu (2006). The variable Z_{it} represents the total amount of loss caused in province i in year t. X, the vector of explanatory variables. X_1 represents demographic factors that affect rates of marriage and divorce, including male/female population ratio, birth rate, share of residents with college and higher education, the proportion of illiterate and semiliterate in the resident population, the total dependency ratio, defined as people aged 0-14 and over 65 to people aged between 15 and 64, population mobility (non-permanent population relative to permanent population). X_2 represents economic factors, including the regional per capita GDP as well as the importance of the service sector, measured as its contribution to GDP. X_3 represents social factors, comprising the share of regional government expenditure devoted to social security and the share of females among employees in towns and cities. α and β are parameters to be estimated. Province fixed effects and year fixed effects are controlled to capture omitted factors. The error term ε_{it} is assumed to have classical OLS properties. In order to investigate the impact of earthquakes on marital behavior in a more specific level, year-prefecture panel regression is also tried in Sichuan province, where Y_{it} represents the rate of marriage(or divorce) of prefecture i in year t. The variable Z_{it} represents the total amount of loss caused in prefecture i in year t. Demographic, economic, and social factors (in year-prefecture level) are also controlled. Tables II to IV show descriptive statistics for all of China (at the provincial level) as well as for Sichuan (at the prefecture level).

Table II reveals huge differences in terms of both marriage and divorce rates between the provinces of China; maximum values exceed minimum values by factors of

Variable	Mean	SD	Min.	Max.	Observations
Marriage rate (percent of population)	0.851	0.315	0.0299	1.850	349
Divorce rate (percent of population)	0.183	0.111	0.00593	0.649	349
Occurrence of earthquake (yes = 1, no = 0)	0.205	0.404	0	1	380
Losses due to earthquakes (mn.)	2,433	43,974	0	856,791	380
Mobility rate (percent)	3.704	75.47	−848.0	89.97	380
Male/female ratio (female = 100)	104.2	3.576	92.84	115.2	380
Birth rate (percent)	1.186	0.326	0.502	2.320	380
Total dependency ratio (percent)	38.34	7.735	19.27	64.49	380
College degree or higher (percent)	6.516	4.889	0.0800	32.61	380
Illiterate or semiliterate (percent)	10.26	7.922	1.700	66.18	380
Per capita GDP (CNY)	19,109	15,701	2,475	85,213	380
Service sector (percent of GDP)	39.39	7.248	28.62	76.07	380
Social security spending (percent of gov't expenditure)	9.105	5.865	0.750	74.47	380
Female share, town and city employees (percent)	37.06	3.053	31.55	57.98	380

Table II. Descriptive statistics (China, 2000-2011)

are 62 and 109, respectively. The same is true of mobility rates, with a negative value indicating emigration (mainly from rural to urban areas). However, the differences in the shares of people with college degree and of limited or no literacy, in GDP per capita, and in social security as share of government spending do not only reflect regional discrepancies but also rapid change over the observation period.

Table III relates to Sichuan, a province that is especially affected by earthquakes, which occurred with a frequency of 4.789 percent of their prefecture-years. In Sichuan, maximum loss comes close to the all-China maximum value exhibited in Table II.

In Table IV, provinces that had more than ten earthquakes between 1999 and 2011 are designated as provinces with a high frequency of earthquakes. A *t*-test on the differences in rate of marriage and divorce suggests that the rates of marriage do not differ; however, it supports the notion that rates of divorce in provinces with high frequency of earthquakes exceed those in provinces with low frequency.

Table V shows regression results at provincial level. Columns (1)-(3) refer to the marriage rate. Contemporaneous losses due to earthquakes are significantly negative but significantly positive when lagged by one year[4]. Perhaps this is because in the year when earthquakes actually happened, people affected would be engaged in disaster relief and trying to get back to regular life trace; the impact of earthquakes on marital decisions tends to manifest itself in the following year of earthquakes. The elasticity is only 1.92×10^{-2}, implying that a doubling of losses may lead to an increase of 1.92 percent in the marriage rate[5]. In column (3), both contemporaneous and lagged losses due to earthquakes are excluded to check whether the other coefficients support earlier findings. This is indeed the case in that a higher rate of marriage goes along with higher mobility and birth rate. Interestingly, a high male/female ratio seems to discourage marriage – with

Table III.
Descriptive statistics (Sichuan, prefecture-level data, 2000-2011)

Variable	Mean	SD	Min.	Max.	Observations
Marriage rate (percent of population)	0.592	0.203	0.0824	1.149	230
Divorce rate (percent of population)	0.120	0.0852	0.0131	0.382	230
Occurrence of earthquake (yes = 1, no = 0)	0.0478	0.214	0	1	230
Losses caused by earthquakes (mn. CNY)	3,729	56,199	0	852,309	230

Table IV.
Rates of marriage and divorce in provinces with high and low frequency of earthquakes

	Marriage rate		Divorce rate	
	Observations	Average	Observations	Average
Provinces with low frequency	312	0.8474949	312	0.1754476
Provinces with high frequency of earthquakes	60	0.8040658	60	0.206906
All provinces	372	0.8404902	372	0.1805215
Provinces with low frequency – provinces with high frequency				
Average	0.0434292		−0.0314584	
t-value	0.9859		−2.0195	
Degrees of freedom	370		370	
p-Value (provinces with low frequency < provinces with high frequency)	0.8376		0.0221	
p-Value (provinces with low frequency > provinces with high frequency)	0.1624		0.9779	

Table V.
The effects of earthquakes on marriage rate and divorce rate (provincial level)

Variables	Marriage rate (1)	(2)	(3)	Divorce rate (4)	(5)	(6)
Losses due to earthquakes in year t	−2.28e−07 (4.74e−08)***			−3.15e−08 (1.11e−08)***		
Losses due to earthquakes in year $t-1$		6.73e−08 (4.38e−08)			4.59e−08 (1.13e−08)***	
Population mobility rate	0.000497 (0.000127)***	0.000498 (0.000127)***	0.000498 (0.000127)***	6.13e−05 (2.38e−05)**	6.15e−05 (2.38e−05)**	6.14e−05 (2.37e−05)**
Male/female	−0.00513 (0.00554)	−0.00530 (0.00553)	−0.00541 (0.00552)	0.00261 (0.00243)	0.00264 (0.00243)	0.00257 (0.00242)
Birth rate	0.307 (0.123)**	0.308 (0.123)**	0.307 (0.123)**	0.00783 (0.0286)	0.00821 (0.0285)	0.00783 (0.0285)
Total dependency ratio	−0.00311 (0.00423)	−0.00311 (0.00421)	−0.00305 (0.00422)	0.00309 (0.00144)**	0.00306 (0.00145)**	0.00310 (0.00144)**
Proportion of pop. with college level/higher education	0.00857 (0.0101)	0.00854 (0.0101)	0.00862 (0.0100)	0.000726 (0.00254)	0.000676 (0.00254)	0.000734 (0.00254)
Proportion of pop. being illiterate or semiliterate	−0.00179 (0.00719)	−0.00197 (0.00719)	−0.00199 (0.00718)	−0.000157 (0.00147)	−0.000175 (0.00147)	−0.000184 (0.00147)
Per capita GDP	−3.32e−06 (1.13e−05)	−3.45e−06 (1.14e−05)	−3.65e−06 (1.14e−05)	9.03e−06 (5.09e−06)*	9.12e−06 (5.08e−06)*	8.99e−06 (5.07e−06)*
Service sector (percent of GDP)	−0.000706 (0.00345)	−0.000642 (0.00341)	−0.000686 (0.00342)	−0.00240 (0.00110)**	−0.00236 (0.00110)**	−0.00239 (0.00110)**
Proportion of spending on social security	−0.000988 (0.00102)	−0.00103 (0.00104)	−0.00107 (0.00104)	−0.000696 (0.000419)	−0.000682 (0.000424)	−0.000708 (0.000425)
Proportion of females among employees in cities	0.00197 (0.00459)	0.00196 (0.00456)	0.00198 (0.00455)	−0.00248 (0.00134)*	−0.00249 (0.00134)*	−0.00248 (0.00134)*
Per capita GDP × Male/female	−3.79e−08 (1.08e−07)	−3.55e−08 (1.08e−07)	−3.38e−08 (1.08e−07)	−8.32e−08 (5.11e−08)	−8.38e−08 (5.10e−08)	−8.27e−08 (5.09e−08)
Constant	0.919 (0.646)	0.937 (0.644)	0.948 (0.643)	−0.0790 (0.276)	−0.0825 (0.276)	−0.0751 (0.275)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	349	349	349	349	349	349
R^2	0.848	0.847	0.847	0.882	0.882	0.882

Notes: Clustered robust standard errors at the provincial level are in parentheses. *,**,***Significance at levels of 10, 5 and 1 percent, respectively

a small mitigating effect of a higher per capita GDP (see the positive coefficient of the interaction variable, "Per capita GDP × Male/female").

Columns (4)-(6) of Table V display analogous regression results for divorce rates. Again, losses due to earthquakes seem to have an encouraging effect on divorce rate. The elasticity of 6.102×10^{-2} implies that a doubling of losses goes along with an estimated increase in the divorce rate of merely 6.102 percent[6]. Since this elasticity exceeds the one pertaining to the marriage rate, the estimated overall effect of earthquakes is to destabilize family relationships. In column (6) of Table V, losses due to earthquakes are again excluded. A new insight is that divorce may also be encouraged by a high per capita GDP and a low proportion of females in urban employment.

4.2 Two extensions of the analysis

Up to this point, statistical inference has been based on highly aggregated provincial data covering all of China. It has produced preliminary evidence suggesting that with a lag of one year, losses due to earthquakes lead to an increase in both marriage and divorce rates. In this section, an extension of this analysis is performed in two directions. First, the specification of Table VI is changed to include more lags in an attempt to test for long-term effects of earthquakes mentioned in the literature. Second, less aggregated data from prefecture-level cities and autonomous prefectures are used; they come from Sichuan, a province especially affected by earthquakes. As the observations are limited in Sichuan, lags of losses due to earthquakes will lead to a further decrease of observations. However, because of high frequency of earthquake occurrences, a three-categorical variable (no earthquake, minor earthquake, and major earthquake) can be introduced into the regression.

To see whether earthquakes have a lasting impact on marriage and divorce rates, the specification exhibited in Table V is extended to include losses due to earthquakes with lags of up to four years (see Table VI). The estimates suggest that marriage and divorce rates might respond to losses that occurred up to two years before, suggesting that effects disappear after three years.

4.3 Using disaggregated data from Sichuan, an especially affected province

Table VII shows regression results when a three-categorical variable (no earthquake, minor earthquake, and major earthquake) has been introduced into the regression with "no earthquake" as the base. Columns (1) and (3) do not show clear patterns of earthquakes' impact on marital decisions while there are clear evidence in columns (2) and (4) that in the following years after earthquakes, compared with prefectures where no earthquakes happened, prefectures hit by minor and major earthquakes have witnessed significantly higher marriage and divorce rates.

In sum, the extensions of the statistical analysis lead to two additional insights. First, the longer-term effects of losses due to earthquakes are unlikely to extend over more than two years after their occurrence. Second, prefectures hit by earthquakes have significantly higher marriage and divorce rates compared with prefectures where no earthquakes happened.

5. Conclusion and recommendations for policy

There are contracting opinions in literature on impact of earthquakes on marriage and divorce rates. Research on stress and economic circumstances tend to believe that natural hazards invite increase of divorce rate and decrease of marriage rate because of PTSD, environmental stress, and negative economic environments. However, there are

Table VI.
Delayed effects of earthquakes on and marriage and and divorce rates

Variables	Marriage rate (1)	(2)	(3)	Divorce rate (4)	(5)	(6)
Losses due to earthquakes in year $t-1$	9.06e – 08 (5.99e – 08)	6.95e – 08 (5.79e – 08)	4.44e – 08 (5.05e – 08)	5.26e – 08 (1.39e – 08)***	4.55e – 08 (1.59e – 08)***	3.91e – 08 (1.46e – 08)**
Losses due to earthquakes in year $t-2$	1.40e – 07 (5.66e – 08)**	1.34e – 07 (5.45e – 08)**	1.17e – 07 (5.02e – 08)**	7.85e – 08 (1.52e – 08)***	7.71e – 08 (1.62e – 08)***	7.48e – 08 (1.39e – 08)***
Losses due to earthquakes in year $t-3$	7.20e – 08 (5.39e – 08)	4.12e – 08 (4.85e – 08)		2.49e – 08 (2.14e – 08)	1.56e – 08 (1.89e – 08)	
Losses due to earthquakes in year $t-4$	6.95e – 06 (3.62e – 05)			1.49e – 05 (1.34e – 05)		
Constant	0.731 (1.184)	0.657 (0.827)	0.790 (0.659)	−0.241 (0.386)	−0.210 (0.348)	−0.268 (0.314)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	257	288	318	257	288	318
R^2	0.848	0.851	0.845	0.885	0.879	0.882

Notes: Clustered robust standard errors at the provincial level are in parentheses. Apart from the explanatory variables reported in the table, those shown in Table V (starting with the mobility rate) were included as well. ***,**Significance at levels of 1 and 5 percent, respectively

Table VII. Effects of earthquakes on marriage and divorce rates (prefecture level, Sichuan 2000-2011)

Variables	Marriage rate (1)	Marriage rate (2)	Divorce rate (3)	Divorce rate (4)
Minor earthquakes in year t	0.0692 (0.0342)*		0.0159 (0.0139)	
Major earthquakes in year t	0.0415 (0.0500)		0.0181 (0.00990)*	
Minor earthquakes in year $t-1$		0.151 (0.0481)***		0.0233 (0.00766)***
Major earthquakes in year $t-1$		0.131 (0.0556)**		0.0333 (0.0117)***
Year fixed effects	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes
Observations	230	230	230	230
R^2	0.835	0.849	0.931	0.933

Notes: Clustered robust standard errors at the prefectural level are in parentheses. Apart from the explanatory variables reported in the table, those shown in Table VI (starting with the mobility rate) were included as well. ***,**,*Significance at levels of 1, 5, and 10 percent, respectively

many different voices believing that marriage rates increase after a disaster due to the incentives to involve in a romantic relationship to cope with stress through social support. This paper seeks to identify the effects earthquakes may have on rates of marriage and divorce in China, a country strongly affected by losses due to earthquakes. Its main finding is that after controlling for demographic, economic, and social factors, in the year when earthquakes actually happen, marriage and divorce rates may decrease in the affected areas perhaps because of the limitation from affected economic and personal physical conditions but the losses have a significant positive effect both on marriage and divorce one year later. Estimated elasticities amount to 1.92×10^{-2} and 6.102×10^{-2}, respectively, implying that a doubling of losses due to earthquakes leads to an increase of 1.92 percent in the marriage and 6.102 percent in the divorce rate. This points to a destabilizing overall effect of earthquakes on family relationships, vindicating some of the earlier qualitative research. The introduction of higher-order lags leads to the conclusion that these effects are unlikely to extend over more than two years after the occurrence of the earthquake. Finally, when the especially hard-hit province of Sichuan is singled out, prefectures hit by earthquakes have both higher marriage and divorce rates than prefectures where no earthquakes happened.

These findings are of potential importance for policy. First, on the whole economic loss due to an earthquake seem to have a destabilizing effect on family relationships, which in view of the low elasticity estimates is likely to be dwarfed by its impact on the region's economic development, however (Xu and Mo, 2013). Second, after-disaster-relief on family relationships are needed and apparently this relief should not be short-term but extend over up to three years in order to deploy its full effect.

However, there are several limitations of this study which may have to be well reconciled in another study. First, a time series analyses would have led to more solid conclusions and solve the problem of correlations between observations. Second, we have found that high marriage and divorce rates tend to appear after earthquakes have happened but are not able to give quantitative analysis about fundamental psychological factors or cultural factors behind this phenomenon. We definitely agree that there are a lot of interesting stories to explore in this field.

Notes

1. The Sichuan earthquake (also called Wenchuan earthquake) occurred on May 12, 2008 and was of magnitude 8.0 at the epicenter. It caused the death of 87,500 people and affected 45.98 mn people affected, with damage amounting to an estimated US$ 850,000 bn. (EM-DAT, 2014).
2. Prior to 2003, the *China Statistical Yearbook* did not report data on earthquake losses by province, and after 2008, the *China Earthquake Yearbook* was no longer published. Therefore, the data for 1999-2007 is taken from the *China Earthquake Yearbook* and the data for 2008-2011, from the *China Statistical Yearbook*.
3. Due to missing data on divorce, two earthquakes had to be excluded.
4. Coefficient of losses due to earthquakes in last year is almost significant (the *p*-value is 0.135).
5. Losses due to earthquakes have a mean of 2,433 mn, marriage rates, of 0.851 percent. A doubling of losses due to earthquakes (an increase by 100 per cent) is associated with a predicted increase of $1.637 \times 10^{-4} (= 2{,}433 \times 6.73 \times 10^{-8})$ percentage points. Compared to the mean of 0.851 per cent, this is an increase by 1.92 percent.
6. Losses due to earthquakes have a mean of 2,433 mn, divorce rates, of 0.183 percent. A doubling of losses due to earthquakes (an increase by 100 per cent) is associated with a predicted increase of 1.117×10^{-4} $(= 2{,}433 \times 4.59 \times 10^{-8})$ percentage points. Compared to the mean of 0.183 percent, this is an increase by 6.102 percent.

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