Stuck in a Marriage: Labor Market Shocks, Divorce and Intra-Household Reallocation*

Wataru Kureishi† Hannah Paule-Paludkiewicz‡

Hitoshi Tsujiyama§ Midori Wakabayashi¶

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Abstract

Families play an important role in providing insurance against adverse shocks, but little is known about how shocks affect the family structure itself. We study the impact of a labor market shock on divorce and intra-household allocation of resources, exploiting a natural-experimental earthquake shock and large-scale panel data. We provide novel evidence that the earthquake reduces the probability of divorce, especially for dual-earner couples. We show that the key driver is the gender-specific labor market shock associated with the earthquake, with female workers experiencing much worse labor market conditions than male workers after the earthquake. The probability of divorce declines because the value of divorce for wives decreases due to the labor market shock, while the value of marriage remains high because of the family insurance provided by the husband to compensate for the wife's loss of income. We show that these results are consistent with a collective household model with limited commitment, and further derive a novel theoretical prediction for the intra-household reallocation of household resources from the wife to the husband. We provide direct evidence for this prediction, using unique panel data with comprehensive information on personal consumption and time use within households.

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†Tokyo Metropolitan University. Email: kurewata@tmu.ac.jp

‡Deutsche Bundesbank. Email: hannah.paule-paludkiewicz@bundesbank.de

§University of Surrey. Email: h.tsujiyama@surrey.ac.uk

¶Tohoku University. Email: midwak@tohoku.ac.jp

1 Introduction

Families play an important role in providing insurance against an adverse economic shock. It is well documented that they adjust within-family decisions, such as labor supply (intensive margin responses), after a shock. However, there is little research on whether and how families change the structure of the family itself, such as divorce (extensive margin responses). Understanding the extensive margin responses is important because they have a significant impact on the degree of family insurance and welfare. This paper studies empirically and theoretically the impact of a labor market shock on divorce and intra-household allocation.

Despite the rich theoretical development since Becker et al. (1977), compelling empirical evidence of responses at the extensive margin is lacking. The primary reason for this is that divorce is a rare event for most people. This poses two major challenges for empirical analysis at the individual level. First, one requires large, long-term panel data with a sufficient number of divorce cases. Second, one needs a large, exogenous shock that affects many individuals, with considerable variation in its intensity, which in itself is rare. Instead, most empirical work has relied on idiosyncratic income shocks, such as job loss, which can be endogenous or expected. Moreover, many important questions remain unanswered. Through what channels does the shock affect marital dissolution? Is the effect heterogeneous across family types, for instance, what is the role of children? Do couples change their intra-household allocation?

To address these empirical challenges, we exploit the large, exogenous natural-experimental earthquake shock of 2011, the Great East Japan Earthquake, whose magnitude was the largest ever recorded in Japan and the fourth largest in the world. It was accompanied by significant variation in its intensity across regions, with intensity being measured by actual ground shaking at observation stations across the country.

We use national birth cohort data, the 2001 cohort of the Longitudinal Survey of Newborns in the 21st Century (hereafter LSN2001). The advantage of this dataset is its unique design and large sample size, with an initial sample of 47,015 households with a child born in 2001, almost all of which are married couples. LSN2001 is also a long panel, available from 2001 to 2018, with limited attrition. The survey's confidential geographic information allows us to merge our household-level data with earthquake intensity for each family. To estimate the impact of the earthquake on marital dissolution, we use difference-in-differences estimation. We exploit the regional variation in the intensity of the earthquake to measure the extent of the treatment. The fact that we observe families both before and after the earthquake allows us to control for time-invariant family

characteristics using household fixed effects.

We provide novel evidence that the earthquake reduces the probability of divorce in both the short and long run, which we call the *bundling effect*. A one standard deviation increase in seismic intensity reduces the probability of divorce by 0.2 and 0.3 percentage points, or 2.7 and 5.0 percent, up to 3 and 7 years after the earthquake. The dynamic difference-in-differences estimation confirms that the bundling effect is persistent and provides evidence for the validity of the parallel trends assumption.

We then investigate the mechanism behind this bundling effect. The key driver is the gender-specific labor market impact associated with the earthquake. In particular, labor market conditions for female workers worsened significantly after the earthquake, with demand for women's jobs falling sharply. In contrast, the impact on male workers is more heterogeneous; their market conditions do not necessarily deteriorate, and may even improve, due to a surge in reconstruction-related demand (Higuchi et al., 2012; Ohta, 2015; Ministry of Health, Labour and Welfare, 2012). After the earthquake, the job-finding rate in the high-intensity areas is lower than in the low-intensity areas for female-dominated sectors, such as services, but higher for male-dominated sectors, such as construction. Using our difference-in-differences framework, we show that the earthquake leads to a significant decline in the labor income of married female workers in both the short and long run in the affected areas, and that this decline is caused by a labor demand shock. On the other hand, the effect of the earthquake on husbands' labor income varies by income type; there is a significant increase in labor income for husbands in dual-earner couples, compensating for the wife's income loss, but not for husbands in single-earner couples. The increase in male earnings is mainly due to sectoral migration into the secondary sector.

This observation has an important implication. Since changing jobs is generally costly, only husbands in dual-earner couples have a reason to do so—a reduction in the wife's earnings. We find that the earthquake-induced decrease in the wives' income in fact leads to an increase in the husbands' income, a form of family insurance against income shocks. The worsened labor market conditions for women thus make wives more financially dependent on their husbands' income, which affects the decision to divorce. In particular, the income loss substantially reduces the value of divorce for a wife, because if she divorces, she will have to live as a single mother with limited resources. On the other hand, the value of marriage remains high because of the family insurance provided by the husband's income compensation. The relative decline in the value of divorce explains the decrease in the probability of divorce, similar to the conceptual framework by Becker (1974) and Becker et al. (1977). In other words, wives who would otherwise divorce

become more financially dependent after an income loss and thus stay married to avoid a painful divorce. This argument is supported by our finding that the bundling effect is much more pronounced for dual-earner couples where the wife experiences an income loss than for single-earner couples where the wife does not have a market job before the earthquake and thus the value of divorce is reduced only by worsened future job prospects. To provide direct evidence for this mechanism, we also conduct instrumental variable estimations using the variation in earthquake intensity to specify instruments for female income. We find a positive and significant effect of female earnings on the probability of divorce, consistent with our proposed mechanism.

We also examine alternative mechanisms that could potentially contribute to the change in divorce patterns. These include stronger family ties after the earthquake in the more affected areas, an increase in the value of insurance following the realization of an unknown event (Knightian uncertainty), and a decline in housing wealth due to the earthquake. We find no evidence that any of these channels is a major driver of our results.

Next, we construct a collective household model with limited commitment, which helps to interpret the channels through which the labor market shock affects the observed divorce patterns. In the model, a dual-earner couple with a young child decides whether to divorce, and then makes decisions about intra-household allocation jointly if they stay married, or separately if they divorce. If they stay in the marriage, they seek an efficient allocation by solving a Pareto problem associated with a Pareto weight (i.e., decision power). The tractable model allows us to solve for the probability of divorce in closed form.

In this environment, we consider a situation in which the wife loses her job due to an unexpected, exogenous earthquake shock and finding a new job involves time costs. The labor market shock makes divorce very costly for the wife because she must find a new job to consume while raising a young child when job opportunities are poor. On the other hand, the value of marriage remains high because of the family insurance; the husband, for whom labor market conditions have hardly deteriorated, finds a higher-paying job to compensate for the tighter household budget. Thus, the relative decline in the value of divorce would induce the wife to avoid divorce even in the face of a low match quality that would normally lead to divorce, resulting in a lower probability of divorce. This bundling effect is less pronounced for the non-working wife in a single-earner couple, as in the empirical findings. Overall, the theory successfully captures the economic forces behind the empirical results on divorce and family insurance.

Since the theory proves useful for understanding the collective decision making of

households, we proceed to establish two novel, testable implications of the theory: intra-household resource reallocation and the role of children in divorce decisions. First, for family insurance, the husband in a dual-earner couple increases his income to compensate for the wife's income loss. In the collective framework, this change in spousal income has two potential effects on the decision power. Namely, if the decision power is a function of relative income, as discussed in Browning et al. (2014), then changes in spousal income will affect how the couple shares resources (Browning et al., 2014; Chiappori and Mazzocco, 2017). Moreover, if the husband's higher income increases the value of divorce for him and thus his participation constraint gets violated, the decision power will be renegotiated so that the husband stays in the marriage to restore individual rationality (Mazzocco, 2007). In both cases, the model implies a new Pareto weight that favors the husband, resulting in an intra-household reallocation of resources from the wife to the husband in terms of consumption and leisure.

The second testable implication of the theory concerns the role of children. The model assumes a large fixed time cost of raising a child because the sample in our main dataset is parents of a young child. If the time cost is small, for example if the couple does not have a child or if the child is already grown up, then the model implies that the shock to female income has only a limited effect on the probability of divorce. This is because the wife is less time-constrained, so finding a new job after divorce is not very costly, leading to little reduction in the value of divorce.

To test these theoretical predictions about intra-household reallocation and the role of children in divorce decisions, we use unique data from the Japanese Panel Survey of Consumers (JPSC). To our knowledge, this dataset is the only existing source of comprehensive information on personal consumption and time use *within* households over time. Using our difference-in-differences setup, we provide novel evidence of intra-household reallocation after the gender-specific labor market shock. Specifically, on days off, when the family's time allocation is flexible, husbands' leisure time increases and childcare and housework time decreases relative to that of wives. In addition, there is an increase in husbands' private consumption, proxied by pocket money, which is typically spent on personal non-work-related items, but this is not the case for wives. Finally, we find that the bundling effect is present for couples with a young child, but not for couples without a child or with a grown-up child, consistent with theory.

In summary, we show empirically and theoretically that families change their divorce decisions in response to an economic shock based on changes in the value of divorce relative to the value of marriage, providing a theoretical justification for the behavioral assumption commonly made in many structural studies since Becker et al. (1977). Wives

facing a severe labor market shock may be stuck in a marriage and have to accept reduced individual welfare in the marriage due to intra-household reallocation. The presence of a young child makes it more difficult for them to choose divorce. These findings suggest that policies to support single mothers, such as generous welfare programs and strict enforcement of child support, would prevent a sharp decline in the value of divorce and thereby improve women's welfare not only in divorce but also in marriage.

Our first contribution is to provide novel individual-level evidence that families change their divorce decisions in response to an unexpected adverse economic shock. Research on whether economic factors affect divorce may date back to Ogburn and Thomas (1922). Many studies have used idiosyncratic shocks such as income or job loss (e.g., Hoffman and Duncan, 1995; Weiss and Willis, 1997; Charles and Stephens, 2004; see also Burstein, 2007 for a review). Several drawbacks to this approach have been recognized. First, a common factor, such as a mental health condition, may simultaneously drive both the likelihood of divorce and the likelihood of income shocks. Also, income shocks may not be fully unexpected. For example, households may have advance information about a drop in income. In the case of a job loss shock caused by a plant closure, it may still be correlated with local economic conditions and thus anticipated.[1] These empirical challenges lead the literature to turn to aggregate shocks.[2] The shocks studied include welfare reforms (e.g., Hu, 2003; Bitler et al., 2004; Low et al., 2023), house price changes (e.g., Rainer and Smith, 2010; Farnham et al., 2011), and trade shocks (e.g., Autor et al., 2019; Keller and Utar, 2022; Irastorza-Fadrique et al., 2023).

Compared to existing studies, our use of the natural disaster shock has a major advantage in that it is completely exogenous and unexpected.[3] It is not correlated with local or aggregate economic conditions, and it occurs in a very short period of time, not after signaling its occurrence long in advance.[4] Moreover, the massive shock affects a

[1] Charles and Stephens (2004) also point out a selection issue; couples who experience an earnings shock (treatment group) and those who do not (control group) may be systematically different in terms of unobserved initial match quality. This is because couples that are poorly matched initially fail quickly before an earnings shock occurs, and are thus more likely to fall into the control group.

[2] The Negative Income Tax programs of the Seattle and Denver Income Maintenance Experiment were thought to provide an ideal setting in this context. However, the analysis and findings have been challenged on methodological and experimental design grounds; see e.g., Cain and Wissoker (1990).

[3] Sen (1983) argues that famine causes divorce. Deryugina et al. (2018) study the long-term economic effects of Hurricane Katrina on its victims, including divorce.

[4] Keller and Utar (2022) use China's entry into the World Trade Organization as a quasi-natural experiment, but define the treatment several years before the actual entry and interpret a decline in women's earnings before entry as anticipation effects. Welfare reforms also tend to be anticipated before they occur. For example, the Personal Responsibility and Work Opportunity Reconciliation Act of 1996, a major welfare reform designed to reduce the number of single mothers in the United States, was enacted two years after Congress passed the major welfare reform bills.

large area, and its intensity is highly heterogeneous. These features allow a very clean identification for empirical analysis. Recent studies use information on lottery winnings, which also allows for clean identification, to examine the effect on divorce conditional on participation (Hankins and Hoekstra, 2011; Bulman et al., 2022; Cesarini et al., 2023; Golosov et al., 2023). The nature of the shock allows them to consider the effect of a one-time positive wealth shock, which is useful for estimating income effects. In contrast, the earthquake resulted in long-lasting negative labor market conditions for women, which is more relevant for family insurance and welfare.

Our second contribution is to elucidate the mechanism behind how the gender-specific labor market shock affects divorce decisions. Many studies have shown that the probability of divorce is positively related to the wife's income, but negatively or not related to the husband's income (e.g., Becker et al., 1977; Weiss and Willis, 1997; Folke and Rickne, 2020; Autor et al., 2019; Bulman et al., 2022; Keller and Utar, 2022; Cesarini et al., 2023; Irastorza-Fadrique et al., 2023). Our paper complements the evidence from these studies by showing both empirically and theoretically that the negative labor market shock makes wives more financially dependent on their partners, which reduces the relative value of divorce and hence the probability of divorce. One important implication of this finding is that individuals may avoid family dissolution to take advantage of family insurance. This is similar in spirit to Kaplan (2012), who shows that living with parents is an important channel of family insurance against labor market risks.

Our third contribution is to provide direct evidence for the theoretical prediction of intra-household resource reallocation. A number of papers have discussed the effects of economic shocks on consumption, leisure, and labor supply in a structural framework. However, testing the model's implications for intra-household allocation is often empirically challenging due to the lack of panel data on individual consumption expenditures and time use.[5] A notable exception is Lise and Yamada (2019), who use the same data we use to test the theoretical predictions. By observing how total household resources are allocated between husband and wife, they are able to estimate how wage differentials and innovations affect intra-household allocation in a structural framework. Our paper provides direct causal evidence that the economic shock leads to a reallocation of resources.

[5]See Chiappori and Mazzocco (2017) for a review. Cross-sectional data on time use and personal expenditures have been employed to estimate the collective model (e.g., Browning et al. 1994; Cherchye et al. 2012; Browning et al. 2024).

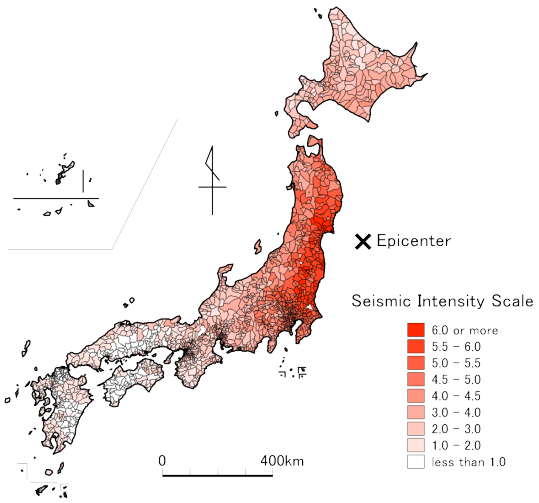


Figure 1: Regional Variation in Earthquake Intensities. The map of Japan shows the average seismic intensity in each municipality on March 11, 2011, based on the Japan Meteorological Agency's Seismic Intensity Scale.

2 Empirical Strategy

2.1 Earthquake Shock

We exploit the Great East Japan Earthquake that occurred on March 11, 2011 as an exogenous shock to the economy. Its magnitude was the largest ever recorded in Japan and the fourth largest in the world. The damage was unprecedented, with 18,425 people dead or missing and 404,893 buildings destroyed or damaged (National Police Agency, 2021). The estimated economic loss of $285 billion in 2021 is the highest of any natural disaster in the world since 1900 (Aon, 2021).

The intensity of the earthquake varied widely across regions, with the Japan Meteorological Agency's Seismic Intensity Scale measured at more than 4,000 observation stations nationwide. Their system quantifies how much ground shaking is occurring based on measurements of peak ground acceleration and the duration of the shaking. Table A.1 summarizes how each seismic intensity level maps to the human perception, indoor and outdoor situation, and damage.[6] Figure 1 shows on a map of Japan the strength of the earthquake as measured by the average seismic intensity in each municipality, with higher intensities indicated by darker colors. It shows the wide variation in intensity across the country.

[6]We do not use the distance from the epicenter because the strength of the earthquake depends on the ground conditions, and even two adjacent points can have very different seismic intensities.

Figure A.1 shows the estimated probability of occurrence of a large seismic intensity at each location over the next 30 years, as assessed in 2010. The probability is high over large areas of Japan, indicating that the area affected by the Great East Japan Earthquake is not special in terms of the probability of a massive earthquake occurring.

2.2 Data

Longitudinal Survey of Newborns in the 21st Century 2001. Our main dataset is the Longitudinal Survey of Newborns in the 21st Century 2001 (LSN2001), a national birth cohort study conducted by the Ministry of Health, Labour and Welfare and the Ministry of Education, Culture, Sports, Science and Technology in Japan. The survey is an annual panel of children born between January 10 and 17, 2001, and July 10 and 17, 2001, and their families. Nearly 90% of all children born during these two weeks participated in the first wave of the survey, resulting in a sample size of 47,015 households.[7] Since only about two percent of children in Japan are born out of wedlock, our sample starts with predominantly married households. The survey collects information on socioeconomic characteristics, family, child care, parenting, health, etc. The confidential geographic information enables us to identify the place of living at the municipality level of each household for each point in time. This allows us to merge our household-level data with information on earthquake intensity.

LSN2001 is available from 2001 to 2018. The survey is conducted twice a year to ensure that children born in January and July are the same age at the time of the survey, except in 2007 when only the July sample was surveyed due to a change in the timing of the surveys. Since in 2011 one part of the survey took place before the earthquake and the other after, we exclude 2011 from the main analysis.[8] In each year, we observe all members living in a given household. Since marital status is not directly observed, but virtually no married couples with children live apart in Japan (ISSP Research Group, 2017), we consider a couple to be divorced if they live apart for non-work reasons.[9] Our main analysis focuses on the years after 2005 because information on whether a household member lives separately for work is available from 2005 onwards.

We restrict the sample to households for which we have information on whether grandparents live in the same household and the number of children living there, both of which we control for in our main specification. The resulting sample consists of 365,863

[7] Average annual attrition rates are low at about 2.6% and are similar in both high and low earthquake intensity areas.

[8] We include 2011 in a robustness check and the results hardly change.

[9] This tendency for married couples to live together is particularly pronounced in Japan. Figure A.2 shows an international comparison. We also show the divorce rate across countries in Figure A.3.

Table 1: Summary Statistics (LSN2001, Pre-Treatment)

Variable	mean	s.d.	Earthquake Intensity	
			High	Low
Divorce (%)	5.8	23.4	5.4	6.1
Number of children	2.2	0.8	2.1	2.2
Grandparent(s) cohabiting (%)	24.6	43.1	24.3	24.8
Employment, wives (%)	55.4	49.7	52.4	57.1
Employment, husbands (%)	99.0	10.2	99.1	98.9
Earnings, wives (m yen)	0.84	1.72	0.87	0.83
Earnings, husbands (m yen)	5.32	5.20	5.78	5.06
Dual-earner couples (%)	51.7	49.9	50.1	52.6
Observations	165,456		58,358	107,098

Note: The high seismic intensity area corresponds to any region that has experienced a seismic intensity greater than or equal to 4.5. The earnings of wives and husbands measure their respective annual pre-tax labor income in millions of yen. We define dual-earner couples as those in which the husband works full time and the wife is employed in 2010.

observations and 32,275 households. Table 1 presents summary statistics for our sample for the pre-treatment period. We use the seismic intensity cutoff of 4.5 to define the high-intensity treatment area because the Japan Meteorological Agency classifies this intensity as the level at and above which real economic damage occurs.

The favorable features of LSN2001 provide key advantages for our empirical analysis of divorce. First, the large size of the sample, which are almost all married couples, allows us to observe a sufficient number of divorce cases. Second, the long panel dimension allows us to follow families for many years in both the pre- and post-earthquake periods.

Japanese Panel Survey of Consumers. We complement our analysis with another household survey, the Japanese Panel Survey of Consumers (JPSC). JPSC is an annual household survey of women, with a new cohort of women added about every five years. Despite its smaller sample size than LSN2001, we use this dataset because of its unique feature. To our knowledge, JPSC is the only existing source of comprehensive information on the intra-household allocation of *individual* time use and consumption over time. It also provides marital status and detailed job information, and covers different types of families, such as couples with children of different ages and couples without children. These features make the dataset well suited for our analyses of intra-household allocation and the role of children in divorce.

We use data from 2008 to 2018 and restrict our sample to couples who were already married in 2008 to avoid endogenous selection into the sample after the earthquake. We

exclude the cohort added in 2013 because their marital status in 2008 is unknown. As in LSN2001, our main sample consists of families with at least one young child (under ten in 2011). To be consistent with the treatment of LSN2001, we exclude 2011 and retain only households with information on whether grandparents live in the same household and the number of children living there. The resulting sample consists of about 580 households and 3,800 observations. Table A.2 provides summary statistics for the JPSC sample.

2.3 Estimation

We use a difference-in-differences design to study the effect of the earthquake on marital dissolution, labor market outcomes, and intra-household allocation. We exploit regional variation in the intensity of the earthquake to measure the extent of the treatment. The fact that we observe families both before and after the earthquake allows us to control for time-invariant family characteristics using a household fixed effects model. We estimate

$$D_{irt} = \alpha_t + \alpha_i + \beta Treat_r \times Post_t + X'_{irt}\gamma + u_{irt}, \tag{1}$$

where D_{irt} is the outcome variable of household i in municipality r and time period t. In the case of our main outcome variable, i.e., divorce status, it is a dummy variable equal to one if the couple is divorced and zero otherwise. α_t are survey year fixed effects, and α_i are household fixed effects that control for all time-invariant observed and unobserved characteristics of the family, such as the parents' education levels, the child's gender, and the couple's initial match quality. The variable $Treat_r$ is a measure of the intensity of the earthquake in municipality r in which the household lived immediately before the earthquake. The treatment status is thus predetermined and remains fixed even if the household relocates.

Following Hanaoka et al. (2018), to account for possible nonlinearity in the effects of the earthquake intensity, we consider the following specification that allows the treatment effect to be kinked: $\mathbb{I}\{T_r \geq 4.5\}(T_r - 4.5)$, where $\mathbb{I}$ is the indicator function that takes one if the condition is satisfied and zero otherwise, and T_r measures the seismic intensity in municipality r. We also use the seismic intensity cutoff of 5 as robustness. The variable $Post_t$ is a dummy variable equal to zero for pre-earthquake periods and one for post-earthquake periods. X_{irt} are time-varying controls, such as the number of children living in the same household and whether any of the grandparents live there. The standard errors are clustered at the household level. Finally, β is the coefficient of interest that measures the effect of earthquake intensity on couples' divorce patterns. To facilitate

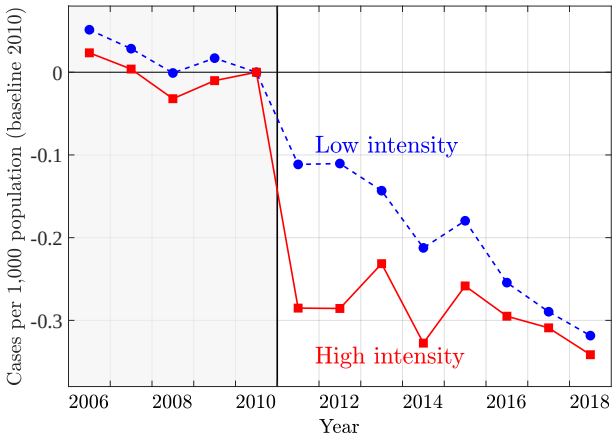


Figure 2: Crude Divorce Rates at the Prefecture Level. The figure shows the number of new divorces per 1,000 population, relative to 2010. The time of the earthquake is indicated by the vertical line. The prefectures of Fukushima, Iwate and Miyagi are the high-seismic intensity areas. Source: Vital Statistics from the Ministry of Health, Labour and Welfare, population estimates from the Statistics Bureau, the Ministry of Internal Affairs and Communications.

interpretation of the regression results, we estimate equation (1) using a linear probability model in the baseline.

3 Main Result: Decline in Divorce

We document the causal effect of the earthquake shock on divorce using the empirical strategy outlined in Section 2.3.

First, we provide striking descriptive evidence at the aggregate level. Figure 2 shows the evolution of crude divorce rates, measured by the number of new divorces per 1,000 population, relative to 2010 at the prefecture level, grouped into a high and a low seismic intensity area. Divorce rates in the two areas are similar before the earthquake, but after the shock, the high-intensity area experiences much lower divorce rates than the low-intensity area, and the gap persists for a long time. This novel aggregate-level finding motivates causal analysis at the individual level.

Causal Estimation of the Bundling Effect. Table 2 shows the short- and long-term effects of the earthquake on divorce, up to 3 and 7 years after the earthquake, using equation (1) based on LSN2001 data.[10] We use two different intensity cutoffs, namely 4.5 and 5, to define the treatment group. Columns (1) and (4) present the results when

[10]The results are robust when we use a logit model and when we specify the treatment variable as a dummy variable instead of a kinked variable (Table A.3). The results are also robust in the JPSC sample (Table 8).

Table 2: Effect of the Earthquake on Divorce

	Treat: seismic intensity $\geq$ 4.5			Treat: seismic intensity $\geq$ 5		
	(1)	(2)	(3)	(4)	(5)	(6)
A: Short run (–2014)						
Treat×*Post*	−0.006**	−0.005**	−0.005*	−0.011**	−0.011**	−0.009**
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
Number of children		✓	✓		✓	✓
Grandparent cohabiting			✓			✓
Observations	258,991	258,991	258,991	258,991	258,991	258,991
# households	35,275	35,275	35,275	35,275	35,275	35,275
B: Long run (–2018)						
Treat×*Post*	−0.010***	−0.008***	−0.008***	−0.017***	−0.018***	−0.017***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)
Number of children		✓	✓		✓	✓
Grandparent cohabiting			✓			✓
Observations	365,863	365,863	365,863	365,863	365,863	365,863
# households	35,275	35,275	35,275	35,275	35,275	35,275

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on divorce using equation (1) based on the LSN2001 dataset. Panels A and B refer to the short- and long-run effects up to 3 and 7 years after the earthquake, respectively. We use a seismic intensity of 4.5 and 5 as thresholds to define the treatment group. All specifications include household fixed effects and year fixed effects. We control for the number of children living in the same household in columns (2) and (5), and additionally for whether a grandparent lives together in columns (3) and (6). Standard errors clustered at the household level are reported in parentheses.

we only control for household and year fixed effects. We find a negative and statistically significant effect of the earthquake on divorce, i.e., couples living in areas more affected by the earthquake are less likely to divorce in both the short and long run, which we call the *bundling effect*. As can be seen, the bundling effect becomes even stronger over time. Adding controls for the number of children living in the same household (columns 2 and 5) and for whether a grandparent lives together (columns 3 and 6) has little impact on the coefficient and significance level. In our preferred specification in column (3), a one standard deviation increase in seismic intensity reduces the probability of divorce in the long run by 0.003, which corresponds to a 4.95% reduction when evaluated against the pre-earthquake divorce rate of 0.054 in the treatment sample.[11] Divorce in Japan is a complicated legal process based on mutual consent. If spouses do not agree to divorce, they must rely on a legal process that can take several years, which partly explains the

[11]The standard deviation of our seismic intensity variable is 0.334.

long-lasting divorce effect.[12,13]

Dynamic Difference-in-Differences Estimation. Next, we consider an event study design that allows us to provide evidence for the validity of the parallel trends assumption and to study the dynamics of the bundling effect. The parallel trends assumption is the identifying assumption for the difference-in-differences approach, which assumes that absent the earthquake, the divorce trends of couples with different treatment intensities would have been the same. To check the plausibility of this assumption, we allow for time-varying treatment effects and interact the treatment variable with year dummies using 2010, the last pre-treatment period, as the baseline year.[14] We estimate

$$D_{irt} = \alpha_t + \alpha_i + \sum_{t \leq 2009} \beta_t Treat_r \times Pre_t + \sum_{t \geq 2012} \beta_t Treat_r \times Post_t + X'_{irt}\gamma + u_{irt}, \tag{2}$$

where Pre_t and $Post_t$ are annual dummy variables for the period before and after the earthquake, respectively. All the other variables are defined as before. For the purposes of the event study, we consider the entire period covered by the dataset, from 2001 to 2018, to take advantage of a longer pre-treatment period that helps shed light on the parallel trends assumption.

Figure 3 presents the results. Consistent with the parallel trends assumption, the coefficients in the pre-earthquake period are largely insignificant and fluctuate around zero with no trend. In contrast, the coefficients turn negative after the earthquake and the impact increases in absolute terms over time, similar to the long-lasting bundling effect found in Table 2.

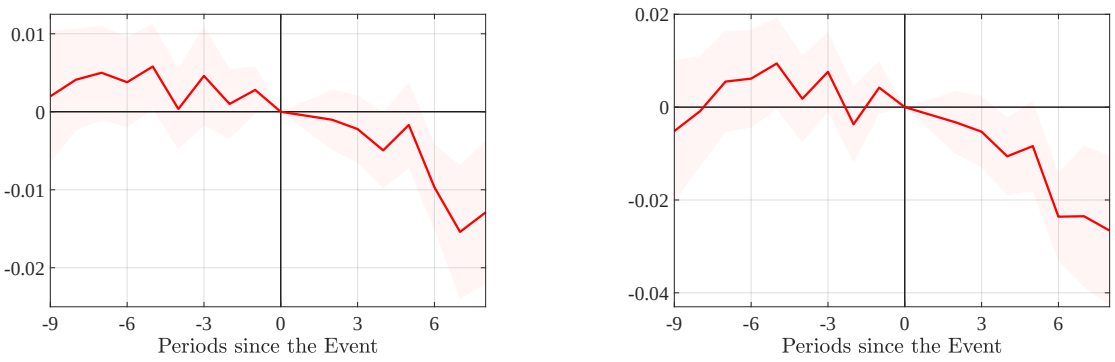
4 Mechanism: Gender-Specific Shock and Value of Divorce

We investigate the mechanism driving the decrease in the probability of divorce in response to the earthquake. We provide evidence that the key driver is the gender-specific labor market impact caused by the earthquake. The resulting changes in the value of divorce and family insurance, in turn, affect divorce decisions. Finally, we discuss other possible mechanisms.

[12] There are four legal grounds for divorce without the consent of the spouse: collaborative divorce, divorce by court mediation, divorce by court order, and divorce by court decree.

[13] The disruption of local government institutions that hindered the filing of divorces was limited, and the legal process returned to normal within a month, even in the most affected areas (Local Authorities Systems Development Center, 2012).

[14] The results are robust when we include 2011 and use it as the baseline (Figure A.4).



(A) Treatment: seismic intensity ≥ 4.5 **(B)** Treatment: seismic intensity ≥ 5

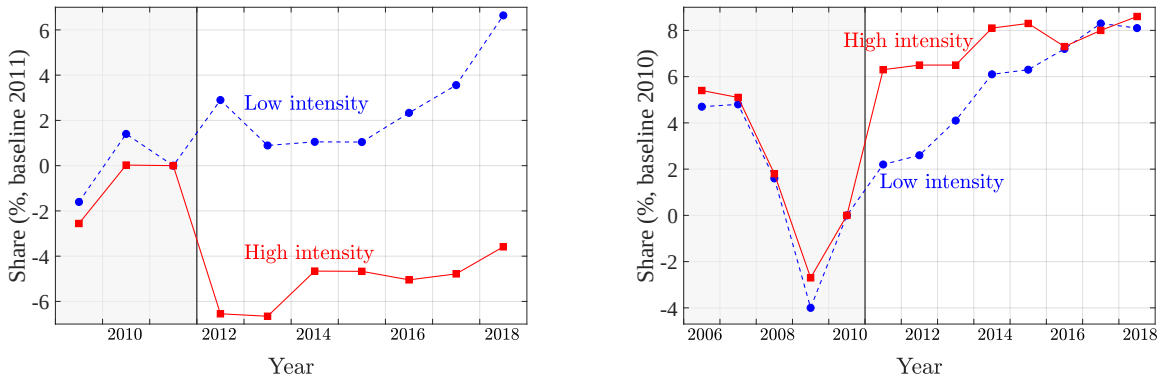
Figure 3: Dynamic Effect of the Earthquake on Divorce. The figure shows estimates of the impact of the earthquake on divorce using equation (2) based on the LSN2001 dataset. The estimation includes household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. The red solid lines show the coefficients of the interaction terms with year dummies. The shaded areas indicate 90% confidence intervals. Standard errors are clustered at the household level.

4.1 Gender-Specific Labor Market Impact of the Earthquake

Descriptive Evidence on Gender-Specific Employment Shock. Some post-earthquake studies have documented that the earthquake results in a gender-specific labor market shock (e.g., Higuchi et al., 2012; Ohta, 2015; Ministry of Health, Labour and Welfare, 2012). In particular, labor market conditions for female workers worsen significantly after the earthquake, with demand for women's jobs falling sharply, whereas the impact on male workers is more heterogeneous; their market conditions do not necessarily deteriorate, and may even improve, due to a surge in reconstruction-related demand.

Figure 4 illustrates the worsened labor market conditions for female workers compared to male workers. Panel A plots the number of female employees as a percentage of the total number of full-time employees for high- and low-seismic intensity areas based on a large-scale national representative household survey.[15] The female employment share follows the increasing national trend in the low-intensity area, but declines and stagnates in the high-intensity area after the earthquake. Panel B plots the share of female unemployment insurance beneficiaries over time based on prefecture-level data. We use prefectures to define areas of high- and low-earthquake intensity. While the trends in the two areas are remarkably similar before the earthquake, the share in the high-intensity area increases sharply in 2011, much more than in the low-intensity

[15]We use the Keio Household Panel Survey (KHPS) and the Japan Household Panel Survey (JHPS), the latter of which started in 2009.



(A) Female Employment Share

(B) Female UI Beneficiaries Share

Figure 4: Gender-Specific Labor Market Shock. Panel A plots the share of female workers, relative to 2011, based on the JHPS dataset. We use a seismic intensity of 4.5 as a threshold to define the high-seismic intensity areas. Panel B plots the share of female unemployment insurance beneficiaries, relative to 2010, based on the Ministry of Health, Labour and Welfare's Annual Report on Employment Insurance Services. The prefectures of Fukushima, Iwate, and Miyagi are the high-seismic intensity areas. The time of the earthquake is indicated by the vertical lines. For Panel A, the base year is 2011 because the 2011 survey was conducted in January, two months before the earthquake.

area, before returning to similar levels in 2016. The evidence on unemployment insurance beneficiaries suggests that the negative impact for female workers is due to a demand rather than a supply shock.[16]

Why did the earthquake shock affect women's labor market conditions more negatively than men's? Women and men tend to have different types of jobs, and the earthquake shock affected them differently. Construction, engineering, mining, transportation, and security are predominantly male occupations, while the majority of workers are female in service, food processing, and clerical occupations (Figure A.5). After the earthquake, male-dominated jobs such as construction, civil engineering, and security were relatively plentiful due to the reconstruction boom, but jobs with a high proportion of female workers, such as service and clerical jobs, and jobs in food processing, which is a major sector in the coastal regions of the affected areas, were not (Higuchi et al., 2012; Ohta, 2015).[17]

To understand the persistence of the relatively worse labor market conditions for

[16]The disruption of childcare facilities only had a very short-lived effect on the decline in female labor supply. The number of schools used as evacuation centers in the affected areas peaked at 622 one week after the disaster, quickly dropping to 240 (42) after one (six) month(s), and then to zero after eight months (Ministry of Education, Culture, Sports, Science and Technology, 2014).

[17]Similar to this observation, Alon et al. (2020) argue that the pandemic recession differs from the usual recessions because of the drop in employment related to social distancing measures, which has a greater impact on sectors with a high share of female employment than male.

female workers shown in Figure 4, we look at job opportunities for each gender. Namely, we compute the job finding rate (number of job openings per job seeker) for female- and male-dominated occupations, where female (male) dominance is defined as the share of female (male) workers in that occupation exceeding 60% in 2010 (Figure A.6).[18] The figure shows that after the earthquake, the job finding rate for female-dominated occupations in the high-intensity area decreases more than in the low-intensity area and stagnates, while the rate for male-dominated occupations increases more and remains high for a long time. This makes it more difficult for female workers to find a suitable replacement job after the initial employment shock in the high-intensity area than in the low-intensity area, but easier for male workers.

Estimation Results on Individual Income. We now estimate the effects of the earthquake on labor income at the individual level using difference-in-differences estimation based on equation (1) and the LSN2001 dataset. Table 3 reports a negative and statistically significant effect of the earthquake intensity on the labor earnings of female workers (column 1) both in the short run (through 2014) and in the long run (through 2018). An increase in seismic intensity by one standard deviation is associated with a long-run decline in annual female gross earnings of 0.018 million JPY, which corresponds to a 2.12% reduction relative to the pre-earthquake female earnings of 0.87 million JPY in the treatment sample. There is no statistically significant effect on the earnings of male workers (reduction of only 0.31% relative to the pre-earthquake mean, see column 2).[19] Total household income, which consists of the labor earnings of all household members and other income, does not change significantly after the earthquake for households in high earthquake intensity areas relative to lower earthquake intensity areas (column 3).[20]

In columns (4-6), we contrast the labor earnings of dual-earner couples, where both partners were employed before the earthquake, with those of male workers in single-earner couples, where the husband is almost always the breadwinner in Japan. For the latter, there is no statistically significant change after the earthquake.[21] In contrast, dual-earner couples experience a significant decrease in wives' earnings due to the earthquake, which is compensated by a significant increase in husbands' earnings in both the short and long run.

[18] Job postings with gender restrictions are illegal in Japan.

[19] This and the following results are similar when we use a seismic intensity cutoff of 5 (Table A.4).

[20] There was essentially no financial assistance from the government for earthquake-affected households, except for temporary loans, unless their home was severely damaged or a primary breadwinner was disabled or died.

[21] The rather large standard error in column (6) indicates the high degree of heterogeneity in the effect of the earthquake on the earnings of male single earners.

Table 3: Effect of the Earthquake on Income

	All Households			Dual Earners		Single Earners
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Female earnings	Male earnings	Household income	Female earnings	Male earnings	Male earnings
A: Short run (–2014)						
Treat×*Post*	−0.053**	−0.143	−0.125	−0.057*	0.120**	−0.371
	(0.023)	(0.156)	(0.165)	(0.034)	(0.061)	(0.301)
Observations	103,669	103,669	102,796	45,251	45,251	55,267
# households	30,854	30,854	30,735	13,243	13,243	16,406
B: Long run (–2018)						
Treat×*Post*	−0.055**	−0.055	−0.022	−0.067*	0.108**	−0.200
	(0.022)	(0.132)	(0.143)	(0.035)	(0.054)	(0.254)
Mean (treated)	0.87	5.77	6.80	1.53	5.28	6.25
Observations	196,018	196,018	189,271	84,743	84,743	104,573
# households	31,580	31,580	31,456	13,420	13,420	16,678

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on income using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 4.5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. Income, measured in millions of yen, is available for 2005, 2008, and each year from 2013. We define dual-earner couples as those in which the husband works full time and the wife is employed in 2008, the most recent pre-earthquake year for which income information is available. Standard errors clustered at the household level are reported in parentheses. The row "mean (treated)" reports the pre-earthquake mean in the high-intensity areas of the respective dependent variable and respective sample.

Our additional estimate suggests that the decline in female earnings is due to a reduction in both the extensive and intensive margins (employment and hours worked conditional on being employed, see Table A.5).[22] It is also involuntary; using a variable that asks non-employed women whether they are looking for a job, and focusing on women in pre-earthquake dual-earner couples, we find a significant increase in the job search behavior after the shock in the high earthquake intensity areas (Table A.6), consistent with the aggregate evidence in Figure 4. On the other hand, the increase in male earnings is mainly due to a move into higher-paying jobs. Using JPSC, we

[22]What causes the decline in hours worked by wives? Using the JPSC dataset, we find that the number of employed married women doing piecework at home, called *naishoku*, increases significantly after the earthquake in the high-intensity area, especially in the short term. Naishoku, which consists of simple tasks performed at home (e.g., decorating, gluing, packing), is very poorly paid and is usually considered a last resort for making money. Some women who became unemployed as a result of the earthquake and could not find a replacement job switched to naishoku, which may explain some of the decline in hours due to substitution effects for employed married women.

Table 4: Heterogeneous Bundling Effects

	Treat: seismic intensity $\geq$ 4.5			**Treat: seismic intensity $\geq$ 5**		
	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All	Dual Earners	Single Earners	All	Dual Earners	Single Earners
Treat×*Post*	−0.007***	−0.009**	−0.006*	−0.015***	−0.021***	−0.009
	(0.003)	(0.004)	(0.003)	(0.004)	(0.006)	(0.006)
Observations	333,709	172,291	161,418	333,709	172,291	161,418
# households	32,062	16,558	15,504	32,062	16,558	15,504

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on divorce using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 4.5 and 5 as thresholds to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. We define dual-earner couples as those in which the husband works full time and the wife is employed in 2010, the last pre-earthquake year, and use the sample with the employment information. Standard errors clustered at the household level are reported in parentheses.

find evidence for sectoral migration of husbands into the secondary sector (Table A.7), consistent with the higher labor demand for reconstruction-related jobs shown in Figure A.6.[23] Labor margins do not appear to be the main driver of the increase in earnings; hours worked by husbands show little increase, and the extensive margin is not affected by the earthquake (Table A.8).

Despite the high job finding rate for male-dominated occupations in the high-intensity area, the significant increase in earnings is experienced only by husbands in dual-earner couples and not by those in single-earner couples (Table 3, columns 5-6). This observation has an important implication. Since changing jobs is generally costly, only husbands in dual-earner couples have a reason to do so—a reduction in the wife's earnings. In fact, our estimates show that the stronger the positive effect of the earthquake on male earnings, the larger the decline in female earnings (Table A.9). This is a form of family insurance against income shocks that has long been recognized in the literature (see Fehr and Kindermann, 2020 for a review). Since the worsened labor market conditions for women make wives more financially dependent on their husbands' income, the earthquake shock would affect the decision to divorce, which we explore next.

4.2 Mechanism: Value of Divorce and Family Insurance

To understand the mechanism, we first focus on the heterogeneity of the bundling effect across dual-earner and single-earner families, hinted at Table 3, which shows the differential effect on income for these different family income types. Table 4 reports the long-run divorce effects for the full sample with available employment information (columns 1 and 4), dual-earner couples (columns 2 and 5), and single-earner couples (columns 3 and 6) based on difference-in-differences regressions. It shows that the decline in the probability of divorce is much more pronounced for dual-earner families than for single-earner families.[24]

This heterogeneous bundling effect across income types is related to the heterogeneous impact of the earthquake on labor income (Table 3) and can be interpreted by the change in the value of divorce and family insurance. When a wife's income declines, the value of divorce decreases because if she divorces, she will have to live as a single mother with limited resources.[25] On the other hand, the value of marriage remains high because of the family insurance provided by the husband's income compensation. The larger decline in the value of divorce than in the value of marriage explains the significant reduction in the probability of divorce for dual-earner couples; wives who would otherwise divorce become more financially dependent after an income loss and thus stay married to avoid a painful divorce.[26] This argument also explains the muted bundling effect for single-earner couples; the wife has no market income before the earthquake, so the value of divorce is reduced only by worsened future job prospects. We formalize this argument in a theoretical framework of collective household decision making in Section 5.

Moreover, our proposed mechanism is also consistent with the finding that the bundling effect is much more pronounced for households with pre-earthquake income below the median (Table A.10). These poor households tend to accumulate less wealth during marriage, so that wives receive little property upon divorce, making them more financially dependent on their husbands' labor income after the labor market shock.[27]

[23] Note that the LSN2001 dataset does not contain sector information.

[24] The difference in coefficients in columns (2-3) is not statistically significant, whereas the coefficients in columns (5-6) are significantly different (p-value: 0.018).

[25] Child support enforcement is not very effective in Japan. In 2011, only 19.7% of single-parent households received child support (Ministry of Health, Labour and Welfare, 2011).

[26] If labor market conditions for male workers improve substantially, the value of divorce for husbands may increase, thereby mitigating the bundling effect. However, our empirical results in Table 3 suggest that the improvement is limited because there is no increase in the husband's income in single-earner couples, and this does not offset the primary force from the wife's side.

[27] In Section 5.2, we also show in our theoretical framework that the bundling effect is more pronounced when the degree of family insurance is more substantial, in the sense that the husband's increased income sufficiently compensates for the wife's lost income, which is more likely to be the case for low-income

Table 5: Instrumental Variables Estimation

	(1)	(2)
Panel A: First Stage (dependent variable: Female Earnings)		
Treat×*Post*	−0.055**	
	(0.022)	
Treat×*Post*×*Minimum Wage*		0.001**
		(0.0005)
Treat×*Post*×*Full-Time*		−0.071
		(0.113)
Anderson-Rubin Wald Test χ^2	9.14	8.14
p-value	0.002	0.017
Panel B: Second Stage (dependent variable: Divorce Probability)		
Female earnings	0.107**	0.075*
	(0.055)	(0.044)
Observations	196,018	181,522
# households	31,580	29,242

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows results of instrumental variables estimation using equation (3) based on the LSN2001 dataset. We use a seismic intensity of 4.5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for the number of children and for whether the grandparents live in the same household. We control for *Treat*×*Post* in column (2). Earnings are measured in million yen. Standard errors clustered at the household level are reported in parentheses.

Instrumental Variables Estimation. To provide more direct evidence of the mechanism discussed above, we conduct an instrumental variables estimation. This approach allows us to extract and quantify the effect of the earthquake-induced reduction in female income on the probability of divorce. We run a two-stage least-squares fixed effects regression:

$$D_{irt} = \alpha_t + \alpha_i + \beta Y^w_{irt} + X'_{irt}\gamma + u_{irt}. \tag{3}$$

In the baseline model, we instrument female earnings Y^w_{irt} with the interaction term $Treat_r \times Post_t$, using the variation in female earnings induced by the earthquake across regions. Column (1) of Table 5 shows the results. The first-stage result in Panel A, which corresponds to the long-run effect reported in Table 3 (Panel B, column 1), shows the negative effect of earthquake intensity on female earnings. The Anderson-Rubin Wald test suggests that the instrument is relevant. The second-stage result in Panel B shows a

households.

positive and significant effect of female earnings on the probability of divorce in line with the reduced-form evidence in Table 2. A decrease in annual female earnings by 1 million JPY (about $7,000) reduces the probability of divorce by 10.7 percentage points.

The exclusion restriction requires that the instrument affects the probability of divorce only through female income. In Section 4.3, we discuss alternative mechanisms through which the probability of divorce could be affected by the earthquake, and indeed find no evidence for any other channel. Nevertheless, to address the potential concern about our instrument, we complement the analyses with an alternative strategy. Specifically, we interact the interaction term $Treat_r \times Post_t$ with the pre-earthquake minimum wage in the prefecture in 2010, $Minimum\ Wage_r$, and a dummy variable that equals one if the wife works full time before the earthquake and zero otherwise, $Full\text{-}Time_{ir}$.[28] We use these two triple interaction terms as instruments for female earnings Y^w_{irt}. Importantly, this approach allows us to control for $Treat_r \times Post_t$ in both the first and second stages, thereby netting out any other potential mechanisms that do not vary with the minimum wage or women's full-time employment status. Using this interaction design, the reduced-form coefficients (i.e., the coefficients of the instruments when the divorce dummy is regressed directly on the instruments) measure only how the slope between earthquake intensity and the probability of divorce changes depending on whether the wife works full-time and depending on the prevailing minimum wage. Thus, the interaction design reduces the plausibility that the reduced-form coefficients reflect other potential mechanisms, making it more likely that the exclusion restriction holds.

Column (2) of Table 5 shows the results.[29] The Anderson-Rubin Wald test suggests that the instruments are relevant. In Panel B, we again find a positive and significant effect of female earnings on the probability of divorce. The estimate in column (2) is only slightly smaller than the estimate in column (1). The result suggests that a decrease in annual female earnings by 1 million JPY reduces the probability of divorce by 7.5 percentage points. These results underscore the importance of the earthquake-induced reduction in female income for the bundling effect.

[28] The minimum wage is adjusted annually in October and varies across prefectures.

[29] In the first stage regression, the triple interaction term with the full-time dummy has a negative coefficient, likely reflecting the fact that in the event of a job loss due to the earthquake, the reduction in earnings is larger for women with a full-time job. The interaction term with the minimum wage has a positive effect on women's earnings, which could be driven by higher (pre-earthquake) regional minimum wages in prefectures with better economic and labor market conditions, so that these regional labor markets are better able to withstand the earthquake shock.

4.3 Alternative Explanations

In this section, we consider alternative mechanisms that could potentially contribute to the change in divorce patterns. While they are not necessarily mutually exclusive with the main mechanism we discussed, we find no evidence that any of these alternative mechanisms is a major driver of the bundling effect (see Appendix B for details).

Family Ties. The earthquake was not only a major economic shock, but also a traumatic event that may have acted as a "love shock," leading to fewer divorces by strengthening family ties. However, this psychological explanation is contradicted by several pieces of evidence.

First, the love shock is likely to be uniform across individuals, which cannot explain the heterogeneity in bundling effects across income types observed in Table 4. We also find heterogeneity across family types using the JPSC dataset. Namely, marital stability increases for families with a young child, but not for families with a grown-up child or without a child (see Section 6). Again, this heterogeneity is inconsistent with the homogeneous love-shock hypothesis. It is still possible that the preference shock interacts with the presence of a child and the child's age. That is, only parents with a young child may not want to subject their children to another traumatic event—parental divorce—after they have already suffered from the earthquake. To test this particular channel, we analyze the survey question from LSN2001 that asks whether or not the presence of the child has strengthened family ties. If children were the reason for not separating after the earthquake, we would expect to find a positive effect of the earthquake on this outcome variable. In contrast, we find a negative and significant effect using our difference-in-differences setup (Table B.1, column 1).

To examine the strength of the marital bond, we also analyze a question from the JPSC that asks about marital satisfaction and find no evidence of an increase in marital satisfaction for couples who experienced a stronger earthquake shock (Table B.1, column 2). In addition, we estimate the effect of the earthquake on higher order fertility based on LSN2001 and find that the probability of having an additional child after the earthquake is lower for couples in high earthquake intensity areas (Table B.1, column 3).[30] These findings can be reconciled with our proposed mechanism of women staying in marriages even with lower match quality for economic reasons, but not with the idea of positive love shocks.[31]

[30] This finding also implies that our divorce results are not driven by the pressure of the biological clock, which may induce fertile women to avoid divorce after a negative labor demand shock (Keller and Utar, 2022).

[31] We also find no statistically significant effect on mental health (Table B.1, column 4).

Value of Insurance. Given that the earthquake was unpredictable (Knightian uncertainty), people may have updated their expectations after the shock. In particular, with the possibility of a deadly natural disaster added to the probability space, they may have begun to value insurance more after the earthquake.

While we cannot directly observe changes in expectations, we can examine the impact of the earthquake on the probability of owning various insurance products (i.e., fire, earthquake, and life insurance) and find no significant changes (Table B.2). Also, we find no increase in marriage rates in the treatment areas at the prefecture level, which is inconsistent with the hypothesized increase in the value of family insurance for the general population (Figure B.1). Finally, Hanaoka et al. (2018) find no evidence of increased risk aversion, which could lead to a higher value of insurance, due to the earthquake shock.

Housing Wealth. The earthquake caused major damage to many residential buildings. It is theoretically and empirically ambiguous how a decline in housing wealth affects divorce (e.g., Rainer and Smith, 2010; Farnham et al., 2011). On the one hand, a decline in house prices means a loss of equity for homeowners, which makes it more difficult to afford two separate homes after a divorce, thereby reducing divorce rates. On the other hand, it could lead to more affordable rents, which in turn would make it easier to split a family in two after a divorce.

Our robustness checks based on LSN2001 suggest that the housing wealth channel is not the main driver of our bundling result (Table B.3). In particular, our result is robust to controlling for property values and the number of damaged houses at the municipality level. Also, the result remains the same even if we exclude areas of very high seismic intensity, where property damage is most severe, or areas where at least 0.01% of the buildings were completely destroyed.[32]

5 A Theoretical Framework: Collective Household Model

In this section, we develop a simple collective household model that helps to interpret the channels through which the labor market shock affects the divorce patterns found in Sections 3 and 4.2. We also make theoretical predictions about intra-household reallocation and the role of children in divorce decisions, which we test empirically in Section 6.

[32]The robustness of our results when excluding areas of very high seismic intensity also suggests that our main result is not driven by differential post-earthquake mortality.

5.1 A Model of Divorce

Our framework is a two-period version of the collective household model with limited commitment (see Browning et al. 2014 and Chiappori and Mazzocco 2017 for a review). The general formulation of the model is presented in Appendix C.1.

Environment. The model has two periods, $t = 1, 2$. There is a married dual-earner couple with a child. In period 1, the couple decides whether to divorce. In period 2, they make decisions about intra-household allocations jointly if they remain married (M), or separately if they divorce (D).

The preferences for each spouse $i \in \{w, h\}$, where w is the wife and h is the husband, are represented by a utility function, $\log(c_i) + \log(\ell_i)$, where c is consumption good and ℓ is leisure. If the couple stays married, the individual utility is given by $\log(c_i) + \log(\ell_i) + \theta_i$, where $\theta_i \in \Theta \subseteq \mathbb{R}$ represents nonpecuniary benefits of marriage, or match quality, which is continuously distributed with a cdf F_θ and realized at the beginning of period 1. We assume that the earthquake does not affect F_θ.

Spouses enter the economy with exogenous income levels $(y_w, y_h) \in \mathbb{R}^2_{++}$. The budget constraint of a married couple and a divorced individual is given by $c_w + c_h \leq y_w + y_h$ and $c_i \leq y_i$ for $i \in \{w, h\}$, respectively.

Spouses are each endowed with 1 unit of time. Assume that having a child requires a fixed parental care time $\bar{n} \geq 0$. One spends ε units of time supplying market labor. The time constraint for $i \in \{w, h\}$ is given by

$$\ell_i + n_i \leq 1 - \varepsilon \mathbb{I}\{y_i > 0\}, \tag{4}$$

where $\mathbb{I}$ is the indicator function, and n_i is childcare time. If the spouses stay together, they split the childcare time:

$$n_w + n_h = \bar{n}. \tag{5}$$

If they divorce, the wife gets custody of the child.[33] In this case,

$$n_i = \begin{cases} \bar{n} & \text{if } i = w, \\ 0 & \text{if } i = h. \end{cases} \tag{6}$$

[33] This is common in Japan. For example, in 2010, among newly divorced couples with a child under the age of 20, 83.3% of child custody was awarded to the wife and 12.9% to the husband with the remainder shared or undetermined. Source: Vital Statistics, Ministry of Health, Labour and Welfare.

Value of Divorce. We first characterize the value of divorce in period 2. When divorced, the spouses live off their individual income. Each $i \in \{w,h\}$ solves

$$V_i^D(y_i) = \max_{\{c_i,\ell_i,n_i\}} \log(c_i) + \log(\ell_i), \tag{7}$$

subject to the budget constraint, $c_i \leq y_i$, and the time constraints (4) and (6). Solving this problem, the value of divorce for the woman in a dual-earner couple is given by

$$V_w^D(y_w) = \log(y_w) + \log(1-\bar{n}-\varepsilon). \tag{8}$$

Value of Marriage. The married couple solves a Pareto problem in period 2. The Pareto weight represents the *decision power* of the spouses (Chiappori and Mazzocco, 2017). Without loss of generality, let μ and $1-\mu$ denote the decision power of the wife and the husband, respectively, which is exogenously given. For now, μ is fixed, and later we consider the possibility that μ changes endogenously.

Given match quality (θ_w, θ_h) and income (y_w, y_h), the couple jointly solves

$$\max_{\{c_i,\ell_i,n_i\}} \mu\left[\log(c_w) + \log(\ell_w) + \theta_w\right] + (1-\mu)\left[\log(c_h) + \log(\ell_h) + \theta_h\right], \tag{9}$$

subject to the budget constraint, $c_w + c_h \leq y_w + y_h$, and the time constraints (4-5).

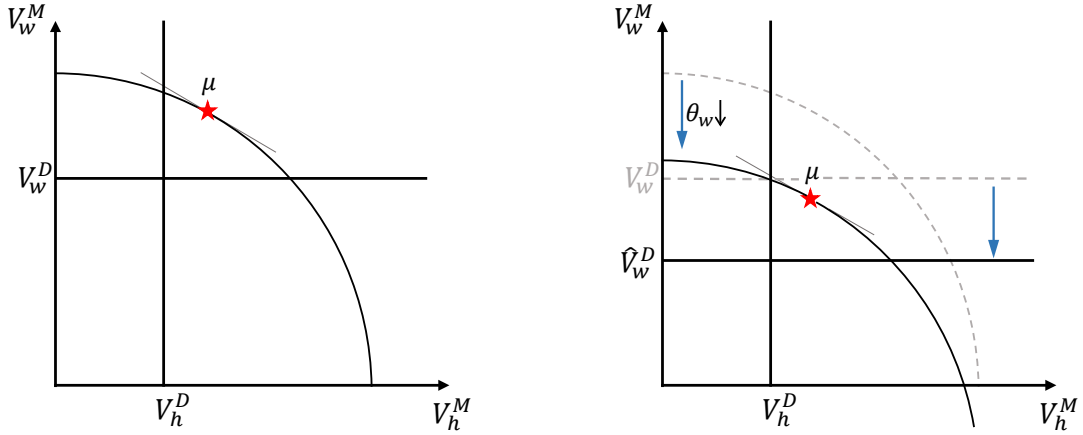
Solving this problem, the optimal allocation is proportional to the total household resources: $\{c_w, c_h, \ell_w, \ell_h\} = \{\mu Y, (1-\mu)Y, \mu T, (1-\mu)T\}$, where $Y = y_w + y_h$ is the household income and $T = 2 - \bar{n} - 2\varepsilon$ is the total non-working time. This proportionality is the standard property of a solution to a Pareto problem, and the proportion is given by the decision power due to log preferences. Given the optimal allocation, the individual value of marriage for the wife in a dual-earner couple is

$$V_w^M(Y,T,\theta_w;\mu) = \log(\mu Y) + \log(\mu T) + \theta_w. \tag{10}$$

Problem of Divorce. We now characterize the household problem of divorce in period 1. The dual-earner couple observes the realization of the match quality (θ_w, θ_h) and decides whether to divorce. We assume unilateral divorce.[34] The participation constraint for $i = \{w,h\}$ (hereafter, PC_i) is given by

$$V_i^M(Y,T,\theta_i;\mu) \geq V_i^D(y_i). \tag{11}$$

[34]This assumption is satisfied in the long run. Although there is no explicit unilateral divorce law in Japan, there are many legal options for divorce without spousal consent (see footnote 12).



(A) Efficient Allocation of a Married Couple

(B) Bundling Effect

Figure 5: Divorce Decisions, Efficient Allocations, and Bundling Effect.

The problem is illustrated in Figure 5A. The Pareto frontier is represented by the arc, and the value of divorce (outside option for marriage) is given by the horizontal line for the wife and the vertical line for the husband. Equation (11) implies that the couple will stay together if the value of marriage (V_w^M, V_h^M) lies on the arc northeast of the outside options. The figure shows an example of such a situation with the red star, and the resulting values chosen by the couple correspond to a specific decision power μ, which determines the slope of the tangent (i.e., $-\frac{1-\mu}{\mu}$).

Note that while marriage provides a benefit of sharing resources between members of the couple, there is another benefit of marriage—match quality θ. This also means that even if the economic gain from marriage is large, divorce can still occur for a sufficiently low (i.e., large negative) realization of θ.

We derive the probability of divorce initiated by the wife, assuming that PC_h is slack (θ_h is sufficiently high). Note that the husband's net nonpecuniary benefit from marriage can be quite high, as it captures the welfare that he derives from the presence of the child, which is reduced upon divorce. There exists match quality θ_w^* that makes the wife indifferent between marriage and divorce, i.e., $V_w^M(Y, T, \theta_w^*; \mu) = V_w^D(y_w)$. Using equations (8) and (10), the break-even match quality satisfies

$$\theta_w^* = \log(y_w) + \log(1 - \bar{n} - \varepsilon) - \log(\mu(y_w + y_h)) - \log(\mu(2 - \bar{n} - 2\varepsilon)).$$

It is easy to check that the divorce decision is monotonic in θ_w; for any $\theta_w < \theta_w^*$, the wife

prefers divorce. The probability of divorce can be thus written as

$$F_\theta \left[\log \left(\frac{1}{\mu^2} \frac{y_w}{y_w + y_h} \frac{1 - \bar{n} - \varepsilon}{2 - \bar{n} - 2\varepsilon} \right) \right]. \tag{12}$$

The probability of divorce is lower if the value in the bracket is lower. The comparative statics shows that from the wife's perspective, all else equal, marriage is more sustainable if μ is higher (the wife receives a higher share of household resources), y_h is higher (husband's income is higher), y_w is lower (wife's income is lower, so becoming a single is more costly), or $\bar{n}$ is higher (raising the child is more costly, especially if she is single).

5.2 Labor Market Shock, Bundling Effect, and Family Insurance

In this section, we show that the shock to the wife's income reduces the probability of divorce—bundling effect—and that it induces the husband in a dual-earner couple to compensate for the wife's income loss as a form of family insurance. We also show that the bundling effect is heterogeneous across family income types.

Gender-Specific Labor Market Shock. In Section 4.1, we document the deterioration of labor market conditions for female workers and the improvement of employment opportunities for male workers after the earthquake. To capture these gender-specific shocks in the model, we consider a situation where the wife's income falls to zero and each individual can find a new job with an income level of y_i', where $y_w' < y_w$ and $y_h' > y_h$. Assume that agents pay a fixed time cost κ to change jobs, where $0 < \kappa < \varepsilon$, and that $\kappa \leq 1 - \bar{n} - \varepsilon$ so that it is feasible for the wife to find a job after the divorce. Denote the job switching decision by $s_i \in \{0, 1\}$.[35]

Bundling Effect and Family Insurance. We now characterize the probability of divorce after the shock. Since the wife has no resources after the divorce, she needs to find a new job, $s_w = 1$.[36] Solving the problem (7), the value of divorce becomes

$$V_w^D(0) = \log\left(y_w'\right) + \log(1 - \bar{n} - \varepsilon - \kappa).$$

The individual value of marriage for the wife is given by equation (10), where the total

[35] Introducing job switching decisions into the model does not change the results obtained so far if the economy is stationary in the sense that the job opportunity is similar to the current job.

[36] Child support is limited in Japan. See footnote 25.

household resources are now

$$\begin{aligned} Y &= s_w y'_w + (1-s_h) y_h + s_h y'_h, \quad \text{and} \\ T &= 2 - \bar{n} - s_w(\varepsilon + \kappa) - \varepsilon - s_h \kappa. \end{aligned}$$

We can characterize job switching decisions under some conditions for (y'_w, y'_h).[37] If y'_w is sufficiently low and y'_h is sufficiently high, there is no incentive for the wife to get a new job, $s_w = 0$, while it is worthwhile for the husband to move to a higher-paying job, $s_h = 1$, thereby compensating for the loss of income as family insurance. In this case, we have $Y = y'_h$ and $T = 2 - \bar{n} - \varepsilon - \kappa$.

As before, we derive the probability of divorce from PC_w, assuming that PC_h is slack. The probability of divorce after the earthquake is given by

$$F_\theta \left[\log \left(\frac{1}{\mu^2} \frac{y'_w}{y'_h} \frac{1 - \bar{n} - \varepsilon - \kappa}{2 - \bar{n} - \varepsilon - \kappa} \right) \right]. \tag{13}$$

Using equations (12-13), the probability of divorce decreases after the shock if

$$\frac{y_w}{y'_w} \frac{y'_h}{y_w + y_h} \frac{2 - \bar{n} - \varepsilon - \kappa}{1 - \bar{n} - \varepsilon - \kappa} \frac{1 - \bar{n} - \varepsilon}{2 - \bar{n} - 2\varepsilon} > 1. \tag{14}$$

This condition is satisfied when women's job opportunities deteriorate sufficiently (y_w / y'_w is sufficiently high), leading to a large reduction in the value of divorce, and when family insurance is substantial ($y'_h / (y_w + y_h)$ is sufficiently high), leading to only a limited reduction in the value of marriage. Condition (14) is also more likely to be satisfied if the job switching cost κ is sufficiently high, which is particularly relevant for a divorced woman. In these cases, the labor market shock makes marriage more sustainable.

The intuition for the bundling effect is simple. With the concave utility function, the labor market shock makes divorce extremely costly for the wife because she must find a new job to consume while raising a young child when job opportunities are poor. On the other hand, the family insurance provided by the husband allows her to maintain a high level of consumption if she stays in the marriage. Therefore, even in the face of a large negative match quality shock, which would normally lead to divorce, the wife chooses to stay in the marriage, in other words, she is stuck in the marriage.

This situation is illustrated in Figure 5B, which shows the decline in the value of divorce, abstracting from the small change in the value of marriage. Suppose there is negative match quality for the wife, which shifts the Pareto frontier downward. With her

[37] These conditions are presented in Appendix C.2.

initial outside option V_w^D (gray dashed horizontal line), there is no feasible allocation that satisfies both participation constraints simultaneously, so divorce occurs. However, with the reduced value of divorce $\hat{V}_w^D$ due to the labor market shock (black solid horizontal line), the efficient allocation indicated by the red star satisfies the participation constraints, so the marriage continues.

Heterogeneous Bundling Effect across Family Income Types. We now turn to the heterogeneity across family income types, as in Section 4.2. Suppose the husband is the sole breadwinner in the couple. Adding job switching decisions to problems (7) and (9), we solve for the value of divorce and marriage for the wife before and after the shock (see Appendix C.2). Using those expressions and PC_w, we show that the bundling effect is also present for the single-earner couple because the wife's job potential deteriorates, $y_w' < y_w$.

Does the model predict a stronger bundling effect for dual-earner couples than for single-earner couples, as in Table 4? Comparing the reduction in the probability of divorce for a dual-earner couple with that for a single-earner couple, this is the case if y_h' is so high that family insurance is substantial and thus the wife in a dual-earner couple finds marriage attractive. The same result is also more likely to hold when κ is higher; the additional cost of divorce imposed by the shock on the wife in a dual-earner couple, but not on the wife in a single-earner couple, is higher.

Our theoretical findings in this section are summarized in the following proposition, the proof of which is found in Appendix C.2.

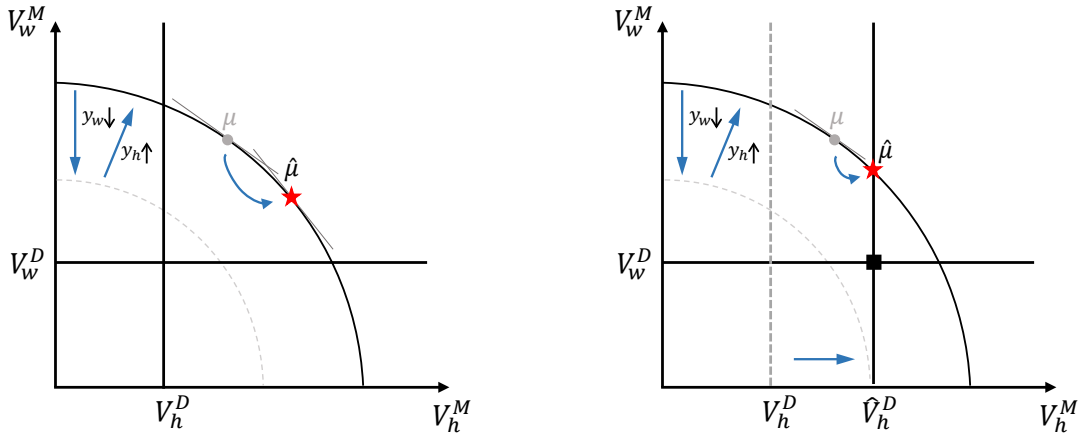
Proposition 1 *Suppose that in a dual-earner couple, the wife's income falls and that her job opportunities are sufficiently poor while the husband's are sufficiently good. Then,*

1. [Family Insurance] *The husband compensates for the loss of the wife's income by moving to a higher-paying job.*

2. [Heterogeneous Bundling Effect] *The probability of divorce decreases for the dual-earner couple. Moreover, the decrease is more pronounced for the dual-earner couple than for the single-earner couple.*

5.3 Theoretical Predictions

We have shown that our collective household framework is useful for understanding the mechanisms behind the empirical results documented in Sections 3 and 4.2. We now derive further theoretical implications, which we test empirically in the next section.



(A) Distribution Factor **(B)** Renegotiation

Figure 6: Endogenous Decision Power μ and Intra-Household Reallocation

Intra-Household Reallocation. We first study the effect on intra-household allocation if the couple avoids divorce by relaxing the assumption that the decision power μ is fixed. In particular, we consider two cases in which it can change endogenously: (i) when it is a function of *distribution factors* and (ii) when there is renegotiation. In both cases, the model predicts an intra-household reallocation of resources from the wife to the husband.[38]

Browning et al. (2014) broadly define the distribution factor as "(a)ny variable that has an impact on the decision process but affects neither preferences nor budget constraints" (p. 123). A prominent example they considered is relative income within a household (see their Table 5.1). Let us write $\mu = g(y_w/y_h)$, where g is an increasing function. In our collective framework, a change in relative income leads to variations in the allocation while the set of efficient allocations remains unchanged. After the shock, the relative income of the dual-earner couple changes, and the decision power may tilt towards the husband, $\hat{\mu} = g\left(0/y_h'\right) < \mu$. The optimal allocation is $\{c_w, c_h, \ell_w, \ell_h\} = \{\hat{\mu}Y, (1-\hat{\mu})Y, \hat{\mu}T, (1-\hat{\mu})T\}$, which implies that for a given set of household resources (Y,T), the wife has less consumption and leisure than in the case of the fixed μ.

Figure 6A illustrates a particular situation where a shift in the Pareto frontier due to a decrease in the wife's income is offset by an increase in the husband's income. On the new Pareto frontier, represented by the arc, the value of marriage (V_w^M, V_h^M) associated with the fixed μ is indicated by the gray dot. When the decision power becomes $\hat{\mu}$ due to the change in relative income, the value of marriage moves to the red star, where the new

[38] In the framework with endogenous decision power, divorce still occurs for sufficiently low match quality (Browning et al., 2014), and the labor market shock leads to the bundling effect shown above because it reduces the value of divorce more than the value of marriage.

tangent is sloped by $-\frac{1-\hat{\mu}}{\hat{\mu}}$.

Second, μ may also change in the event of renegotiation. An important feature of this model is that the individual outside options play a critical role by affecting the intra-household decision power. Suppose the value of marriage (V_w^M, V_h^M) associated with a decision power μ does not satisfy one partner's participation constraint. Renegotiation allows the couple to adjust μ and modify the intra-household allocation so that the participation constraint is satisfied with equality, leading to *ex post* efficiency (Kocherlakota 1996; Ligon et al. 2002). With the possibility of renegotiation, divorce occurs only when there is no feasible allocation of resources that satisfies the participation constraints of both spouses (Browning et al., 2014).

Figure 6B illustrates this point. Suppose that the value of divorce of the husband increases from V_h^D to $\hat{V}_h^D$, represented by the solid vertical line, which can be the case if, e.g., the value is also a function of job opportunities. His participation constraint PC_h is tightened and violated (gray dot). If there is no renegotiation, divorce occurs, resulting in the values $(V_w^D, \hat{V}_h^D)$ given by the intersection of the outside options represented by the black square. However, this outcome is not efficient because there exists a set of feasible Pareto-dominant allocations, represented by the solid arc northeast of the outside options. Now, renegotiation allows the wife, who has a positive surplus from remaining married, to adjust μ to $\hat{\mu}$ so that the husband stays in the marriage and individual rationality is restored. The resulting values $(V_w^M, V_h^M; \hat{\mu})$ are such that $V_w^M > V_w^D$ and $V_h^M = \hat{V}_h^D$, as indicated by the red star. The new decision power $\hat{\mu}$ makes the participation constraint for the husband binding.[39]

In both cases, the decision power decreases from μ to $\hat{\mu}$. This leads to a change in the relative resources in a way that favors the husband, regardless of the level of total household resources after the shock. In other words, the husband now enjoys a larger share of the household resources and thus a higher welfare than in the case of the fixed μ, at the expense of the wife, who has a smaller share and a lower welfare due to the intra-household reallocation. We have the following, the proof of which is found in Appendix C.3.

Proposition 2 [Intra-household Reallocation] *Suppose the decision power μ decreases to $\hat{\mu}$ after the shock. Then the husband's consumption and leisure increase and childcare time decreases, relative to the wife. That is, c_h/c_w and ℓ_h/ℓ_w increase and n_h/n_w decreases.*

Role of Children. Next, we study the role of children in divorce decisions. Halla et al. (2020) emphasize the importance of children for the effectiveness of family insurance.

[39] Note that $\lambda \equiv \mu - \hat{\mu}$ corresponds to the Karush–Kuhn–Tucker multiplier of the participation constraint. See Appendix C.1.

Consider the case where the couple has no child or only a grown-up child, which corresponds to the situation where the time cost $\bar{n}$ is small. Since the left-hand side of equation (14) increases with $\bar{n}$, the divorce effect of the labor market shock becomes smaller. The intuition is as follows. A smaller $\bar{n}$ makes the time constraint less tight. This relaxation of the time constraint is particularly relevant for a divorced woman, because she gains custody (equation 6). With the concave utility for leisure, the value of divorce is not much reduced by the adverse shock. This result is summarized in the following.

Proposition 3 [Role of Children in Divorce] *The bundling effect is greater for a couple with a young child than for a couple with a grown-up child or without a child.*

6 Empirical Evidence on Theoretical Predictions

In this section, we test the implications of the model discussed in Section 5.3.

6.1 Evidence for Intra-Household Reallocation

To empirically study the impact of the earthquake on intra-household reallocation, we turn to JPSC, which to our knowledge is the only existing source of comprehensive information on the intra-household allocation of individual time use and consumption over time. Lise and Yamada (2019) use this dataset to study the dynamics of intra-household allocation in a structural framework.

The first theoretical prediction is a reallocation of resources within the household from the wife to the husband if the couple avoids divorce (Proposition 2). Using difference-in-differences regression (equation 1), we report the impact of the earthquake on individual relative time use during both workdays and days off in Table 6: leisure time in columns (1) and (4), childcare and housework time in columns (2) and (5), and market work time in columns (3) and (6). Leisure time includes time spent on hobbies and recreation as well as time spent on things like sleeping and eating. Childcare and housework time includes time spent on child rearing and house keeping. Market work time consists of time spent at a market job and commuting time. We define the dependent variable as the difference in minutes per day between the time spent on a particular activity by wives and the time spent by husbands, given the theoretical prediction about the relative time use, i.e., $\frac{\ell_w}{\ell_h}$ and $\frac{n_w}{n_h}$.

On workdays, the experience of a stronger earthquake shock reduces the market hours of wives relative to husbands (column 3), consistent with the reduced labor supply of wives documented in Section 4.1 (see also Table A.5). These reduced hours are spent

Table 6: Time Use within Households

	Workday			Day Off		
	(1) Leisure	(2) Childcare/ Housework	(3) Market Work	(4) Leisure	(5) Childcare/ Housework	(6) Market Work
Treat×*Post*	−29.5	79.0***	−54.3**	−63.3**	61.8**	−7.0
	(20.6)	(22.9)	(23.8)	(29.1)	(27.2)	(13.1)
Observations	3,840	3,825	3,823	3,840	3,830	3,772
# households	665	665	665	665	663	661

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on time use using equation (1) based on the JPSC dataset. We use a seismic intensity of 4.5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. We define the dependent variable as the difference in minutes per day between the time spent on a particular activity by wives and the time spent by husbands. Standard errors clustered at the household level are reported in parentheses.

on childcare and housework by wives relative to husbands (column 2). This result can be understood as a natural shift of the individual time budget from market work to housework. In contrast, more than an intrapersonal shift in time use occurs on days off, when the family's time allocation is likely to be more flexible. Specifically, in households experiencing a stronger earthquake shock, there is a significant reallocation of leisure time from wives to husbands and of childcare and housework time from husbands to wives (columns 4-5), in line with the theoretical prediction in Proposition 2.

Next, we examine changes in the allocation of private consumption and savings within households. To capture private consumption, we use the information in the JPSC on monthly pocket money (i.e., allowance/spending money). This is a fixed amount of money paid each month to each member of a household and is typically spent on personal non-work-related items such as private clothing, alcoholic drinks, and cosmetics, making it a good proxy for private consumption. We also consider monthly flow savings that go into the individual's bank account, as opposed to the joint family account. Savings accumulated during a marriage are in principle divided equally upon divorce, regardless of entitlement, so personal savings deposited in an individual's bank account are not relevant to the value of divorce. On the other hand, in practice, one can save unused monthly pocket money into personal savings that will be used for personal consumption in the future within the marriage. Table 7 shows that after the earthquake, husbands in the affected areas are able to increase both the amount of money they can use for private consumption (column 2) and their monthly savings (column 4), while

there is a negative but not statistically significant change for wives. The coefficients for men and women are significantly different from each other, both in the case of monthly pocket money (p-value: 0.004) and monthly savings (p-value: 0.067).[40]

Given the large economic shock, the *increase* in husbands' private consumption and savings stands out. It is consistent with our proposed mechanism of changing the Pareto weight μ in favor of husbands, but difficult to reconcile with the other mechanisms discussed in Section 4.3. Similar to our findings, Lise and Yamada (2019) study how wage differentials and innovations affect intra-household allocation in a structural framework. Our contribution is to provide direct evidence that the economic shock leads to a reallocation of resources. This empirical finding of intra-household reallocation is also consistent with the collective household model, but cannot be explained by a unitary household model that assumes income pooling.[41] Finally, in Section 5.3, we show that if relative income is a distribution factor, its change caused by the earthquake leads to intra-household reallocation.[42] While numerous papers have tested the impact of a change in distribution factors on various outcome variables such as household demand for commodities, labor supply, and leisure (see Table 5.2 of Browning et al. 2014), to our knowledge, our paper is the first to provide the causal evidence of the effect on private consumption. This is an important contribution because private consumption is directly relevant to individual welfare.

6.2 Evidence for the Role of Children in Divorce Decisions

The second testable implication of the theory concerns the role of children in divorce decisions (Proposition 3). Specifically, the model implies that the reduction in the probability of divorce is particularly pronounced for a family with a young child, as divorce is very costly for the wife due to the large cost of raising the child alone. In contrast, a family with a grown-up child or no child has little or no child-rearing costs, so

[40] There is no significant change in overall household savings.

[41] In cross sectional analyses, it is difficult to reject the unitary household model solely on the basis of the existence of a correlation between relative demands and relative earnings. This is because unobserved heterogeneity in tastes may be correlated with heterogeneity in earnings and may explain the observed heterogeneity in demands, and it has been difficult to find instruments to wash out this spurious correlation. In contrast, our panel analysis with the exogenous shock provides strong evidence against the unitary assumption when individual tastes are stable.

[42] We show two non-exclusive scenarios in which a change in decision power leads to intra-household reallocation: a change in the distribution factor and renegotiation. Identifying the channels through which changes in economic conditions affect decision power is empirically challenging. For instance, similar to the first scenario, Chiappori et al. (2002) consider divorce legislation as a distribution factor that affects decision power. On the other hand, similar to the second scenario, Voena (2015) considers a situation where changes in divorce legislation affect allocations through a change in outside options.

Table 7: Private Consumption and Savings within Households

	Pocket Money		Savings	
	(1) Wife	(2) Husband	(3) Wife	(4) Husband
Treat×*Post*	−2.151	5.183**	−0.207	3.835*
	(1.421)	(2.501)	(1.174)	(2.263)
Observations	3,155	2,007	4,092	4,113
# households	604	416	685	685

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on savings and pocket money using equation (1) based on the JPSC dataset. We use a seismic intensity of 4.5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, a control for whether a grandparent lives in the same household, and a control for monthly household income. The dependent variable is the monthly pocket money (columns 1-2) and the monthly savings (columns 3-4) of wives and husbands, respectively, in thousands of yen. Standard errors clustered at the household level are reported in parentheses.

little bundling effect is predicted.

Table 8 shows the results of estimating equation (1) separately for families with different family compositions based on the JPSC data. Column (1) shows a negative and statistically significant effect of the earthquake on divorce rates for families with a young child (families with at least one child under the age of ten in 2011), which is consistent with the result using a comparable sample in the LSN2001. In contrast, we find no divorce effect for families with only old children (families with the youngest child over the age of fifteen, the age at which compulsory education ends) and for childless couples. The estimated bundling effect for families with a young child is significantly different from the effect for families with only old children (p-value: 0.04) and for couples without a child (p-value: 0.07). This finding is similar to Irastorza-Fadrique et al. (2023), who also find a larger effect of trade shocks on divorce in the presence of children. These results validate our theoretical prediction derived in Section 5.3. Moreover, as discussed in Section 4.3, the heterogeneity in the bundling effect helps us reject alternative mechanisms, e.g., the earthquake as a positive love shock leading to a stronger marital bond.

Table 8: The Role of Children in Divorce Decisions

	(1) Young Child	(2) Old Child	(3) No Child
Treat×*Post*	−0.046**	0.004	0.018
	(0.020)	(0.034)	(0.053)
Observations	3,889	3,324	937
# households	585	490	159

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on marital dissolution using equation (1) based the JPSC dataset. We use a seismic intensity of 4.5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. Column (1) refers to couples with at least one child under the age of ten in 2011, column (2) refers to couples with the youngest child over the age of fifteen, and column (3) refers to couples with no children. Standard errors clustered at the household level are reported in parentheses.

7 Conclusions

Families play an important role in providing insurance against adverse economic shocks, but little is known about whether and how families change their structure when such shocks occur. In this paper, we find causal evidence that families change their divorce decisions in response to an economic shock, exploiting a completely unexpected exogenous earthquake shock as a natural experiment. We show empirically and theoretically that this economic decision is made based on changes in the value of divorce relative to the value of marriage, providing a theoretical justification for the behavioral assumption commonly made in many structural studies since Becker et al. (1977).

Our analysis suggests that wives facing a severe labor market shock may be stuck in a marriage and have to accept reduced individual welfare in the marriage due to intra-household reallocation. The presence of a young child makes it more difficult for them to choose divorce. These findings are of great policy relevance. They suggest that policies aimed at helping single mothers, such as generous welfare programs and strict enforcement of child support, would improve women's welfare not only in divorce but also in marriage. Analyzing the effects of these policies on family structure and welfare in a structural framework is an important step toward practical policy recommendations and will be our future work.

References

Alon, T., M. Doepke, J. Olmstead-Rumsey, and M. Tertilt (2020). The Impact of COVID-19 on Gender Equalit. Working Paper 26947, National Bureau of Economic Research. 15

Aon (2021). 2021 Weather, Climate and Catastrophe Insight. Technical report. 7

Autor, D., D. Dorn, and G. Hanson (2019). When Work Disappears: Manufacturing Decline and the Falling Marriage Market Value of Young Men. *American Economic Review: Insights 1*(2), 161–78. 5, 6

Becker, G. S. (1974). A Theory of Marriage: Part II. *Journal of Political Economy 82*(2), S11–S26. 2

Becker, G. S., E. M. Landes, and R. T. Michael (1977). An Economic Analysis of Marital Instability. *Journal of Political Economy 85*(6), 1141–1187. 1, 2, 4, 6, 36

Bitler, M. P., J. B. Gelbach, H. W. Hoynes, and M. Zavodny (2004). The Impact of Welfare Reform on Marriage and Divorce. *Demography 41*(2), 213–236. 5

Browning, M., F. Bourguignon, P.-A. Chiappori, and V. Lechene (1994). Income and Outcomes: A Structural Model of Intrahousehold Allocation. *Journal of Political Economy 102*(6), 1067–1096. 6

Browning, M., L. Cherchye, T. Demuynck, B. de Rock, and F. Vermeulen (2024). Spouses with Benefits: on Match Quality and Consumption inside Households. Mimeo. 6

Browning, M., P.-A. Chiappori, and Y. Weiss (2014). *Economics of the Family*. Cambridge University Press. 4, 24, 30, 31, 34

Bulman, G., S. Goodman, and A. Isen (2022). The Effect of Financial Resources on Homeownership, Marriage, and Fertility: Evidence from State Lotteries. Working Paper 30743, National Bureau of Economic Research. 6

Burstein, N. R. (2007). Economic Influences on Marriage and Divorce. *Journal of Policy Analysis and Management 26*(2), 387–429. 5

Cain, G. G. and D. A. Wissoker (1990). A Reanalyis of Marital Stability in the Seattle-Denver Income-Maintenance Experiment. *American Journal of Sociology 95*(5), 1235–1269. 5

Cesarini, D., E. Lindqvist, R. Östling, and A. Terskaya (2023). Fortunate Families? The Effects of Wealth on Marriage and Fertility. Working Paper 31039, National Bureau of Economic Research. 6

Charles, K. K. and M. Stephens, Jr. (2004). Job Displacement, Disability, and Divorce. *Journal of Labor Economics 22*(2), 489–522. 5

Cherchye, L., B. De Rock, and F. Vermeulen (2012). Married with Children: A Collective Labor Supply Model with Detailed Time Use and Intrahousehold Expenditure Information. *American Economic Review 102*(7), 3377–3405. 6

Chiappori, P., B. Fortin, and G. Lacroix (2002). Marriage Market, Divorce Legislation, and Household Labor Supply. *Journal of Political Economy 110*(1), 37–72. 34

Chiappori, P.-A. and M. Mazzocco (2017). Static and Intertemporal Household Decisions. *Journal of Economic Literature 55*(3), 985–1045. 4, 6, 24, 25, 19

Deryugina, T., L. Kawano, and S. Levitt (2018). The Economic Impact of Hurricane Katrina on Its Victims: Evidence from Individual Tax Returns. *American Economic Journal: Applied Economics 10*(2), 202–33. 5

Farnham, M., L. Schmidt, and P. Sevak (2011). House Prices and Marital Stability. *American Economic Review 101*(3), 615–19. 5, 23, 16, 17

Fehr, H. and F. Kindermann (2020). The Insurance Role of the Family. In *Handbook of Labor, Human Resources and Population Economics*, pp. 1–31. Springer International Publishing. 18

Folke, O. and J. Rickne (2020). All the single ladies: Job promotions and the durability of marriage. *American Economic Journal: Applied Economics 12*(1), 260–87. 6

Golosov, M., M. Graber, M. Mogstad, and D. Novgorodsky (2023). How Americans Respond to Idiosyncratic and Exogenous Changes in Household Wealth and Unearned Income. *The Quarterly Journal of Economics 139*(2), 1321–1395. 6

Halla, M., J. Schmieder, and A. Weber (2020). Job Displacement, Family Dynamics, and Spousal Labor Supply. *American Economic Journal: Applied Economics 12*(4), 253–287. 31

Hanaoka, C., H. Shigeoka, and Y. Watanabe (2018). Do Risk Preferences Change? Evidence from the Great East Japan Earthquake. *American Economic Journal: Applied Economics 10*(2), 298–330. 10, 23, 16

Hankins, S. and M. Hoekstra (2011). Lucky in Life, Unlucky in Love? The Effect of Random Income Shocks on Marriage and Divorce. *Journal of Human Resources 46*(2), 403–426. 6

Headquarters for Earthquake Research Promotion (2010). Zenkoku Jishindou Yosoku Chizu (National Earthquake Motion Prediction Map). Technical report. 1

Higuchi, Y., T. Inui, T. Hosoi, I. Takabe, and A. Kawakami (2012). The Impact of the Great East Japan Earthquake on the Labor Market–Need to Resolve the Employment Mismatch in the Disaster-Stricken Areas. *Japan Labor Review 9*(4), 4–21. 2, 14, 15

Hoffman, S. D. and G. J. Duncan (1995). The Effect of Incomes, Wages, and AFDC Benefits on Marital Disruption. *The Journal of Human Resources 30*(1), 19–41. 5

Hu, W.-Y. (2003). Marriage and Economic Incentives. *Journal of Human Resources 38*(4), 942–963. 5

Irastorza-Fadrique, A., P. Levell, and M. Parey (2023). Household Responses to Trade Shocks. Mimeo. 5, 6, 35

ISSP Research Group (2017). International Social Survey Programme: Work Orientations IV - ISSP 2015. GESIS Data Archive, Cologne. ZA6770 Data file Version 2.1.0, https://doi.org/10.4232/1.12848. 8, 2

Kaplan, G. (2012). Moving Back Home: Insurance against Labor Market Risk. *Journal of Political Economy 120*(3), 446–512. 6

Keller, W. and H. Utar (2022). Globalization, Gender, and the Family. *The Review of Economic Studies 89*(6), 3381–3409. 5, 6, 22, 14

Kocherlakota, N. R. (1996). Implications of Efficient Risk Sharing without Commitment. *The Review of Economic Studies 63*(4), 595–609. 31

Ligon, E., J. P. Thomas, and T. Worrall (2002). Informal Insurance Arrangements with Limited Commitment: Theory and Evidence from Village Economies. *The Review of Economic Studies 69*(1), 209–244. 31, 21

Lise, J. and K. Yamada (2019). Household Sharing and Commitment: Evidence from Panel Data on Individual Expenditures and Time Use. *The Review of Economic Studies 86*(5), 2184–2219. 6, 32, 34

Local Authorities Systems Development Center (2012). Higashinihon Daishinsai ni Okeru Chihokoukyodantaijouhobumon no Hisaiji no Torikumi to Kongo no Taiou no Arikata ni Kansuru Chosahokoku (Report on the Efforts of the Information Sector of Local Governments in the Wake of the Great East Japan Earthquake and the Future Response to the Disaster). Technical report. 13

Low, H., C. Meghir, L. Pistaferri, and A. Voena (2023). Marriage, Labor Supply and the Dynamics of the Social Safety Net. Mimeo. 5

Marcet, A. and R. Marimon (2011). Recursive Contracts. Mimeo. 21

Mazzocco, M. (2007). Household Intertemporal Behaviour: A Collective Characterization and a Test of Commitment. *The Review of Economic Studies 74*(3), 857–895. 4

Ministry of Education, Culture, Sports, Science and Technology (2014). Saigai ni Tsuyoi Gakkoushisetsu no Arikata ni tsuite–Tsunamitaisaku oyobi Hinanjo to shiteno Bousaikinou no Kyouka (Toward Disaster-Resilient School Facilities: Strengthening Disaster Prevention Functions as Tsunami Countermeasures and Evacuation Shelters). Technical report. 15

Ministry of Health, Labour and Welfare (2011). Zenkoku Boshisetaitou Chousakekka Houkoku (National Survey of Single-Parent Households). Technical report. 19

Ministry of Health, Labour and Welfare (2012). *White Paper on Labour and Economy*. Tokyo: Ministry of Health, Labour and Welfare. 2, 14

National Police Agency (2021). White Paper on Police Affairs. Technical report. 7

Ogburn, W. F. and D. S. Thomas (1922). The Influence of the Business Cycle on Certain Social Conditions. *Journal of the American Statistical Association 18*(139), 324–340. 5

Ohta, S. (2015). Rodoshijou kara mita Shinsaichokugo, Fukkoukatei ni okeru Keizaijoukyou (Economic Situation right after the Earthquake and in the Process of Recovery from the Perspective of Labor Market). In *Shinsai to Keizai (Economy and the Earthquake)*, pp. 101–136. Toyokeizai. 2, 14, 15

Rainer, H. and I. Smith (2010). Staying Together for the Sake of the Home?: House Price Shocks and Partnership Dissolution in the UK. *Journal of the Royal Statistical Society: Series A (Statistics in Society) 173*(3), 557–574. 5, 23, 16, 17

Sen, A. (1983). *Poverty and Famines: An Essay on Entitlement and Deprivation*. Oxford University Press. 5

Voena, A. (2015). Yours, Mine, and Ours: Do Divorce Laws Affect the Intertemporal Behavior of Married Couples? *American Economic Review 105*(8), 2295–2332. 34

Weiss, Y. and R. J. Willis (1997). Match Quality, New Information, and Marital Dissolution. *Journal of Labor Economics 15*(1, Part 2), S293–S329. 5, 6, 18

Stuck in a Marriage: The Impact of Income Shocks on Divorce and Intra-Household Allocation

Online Appendix

Wataru Kureishi Hannah Paule-Paludkiewicz

Hitoshi Tsujiyama Midori Wakabayashi

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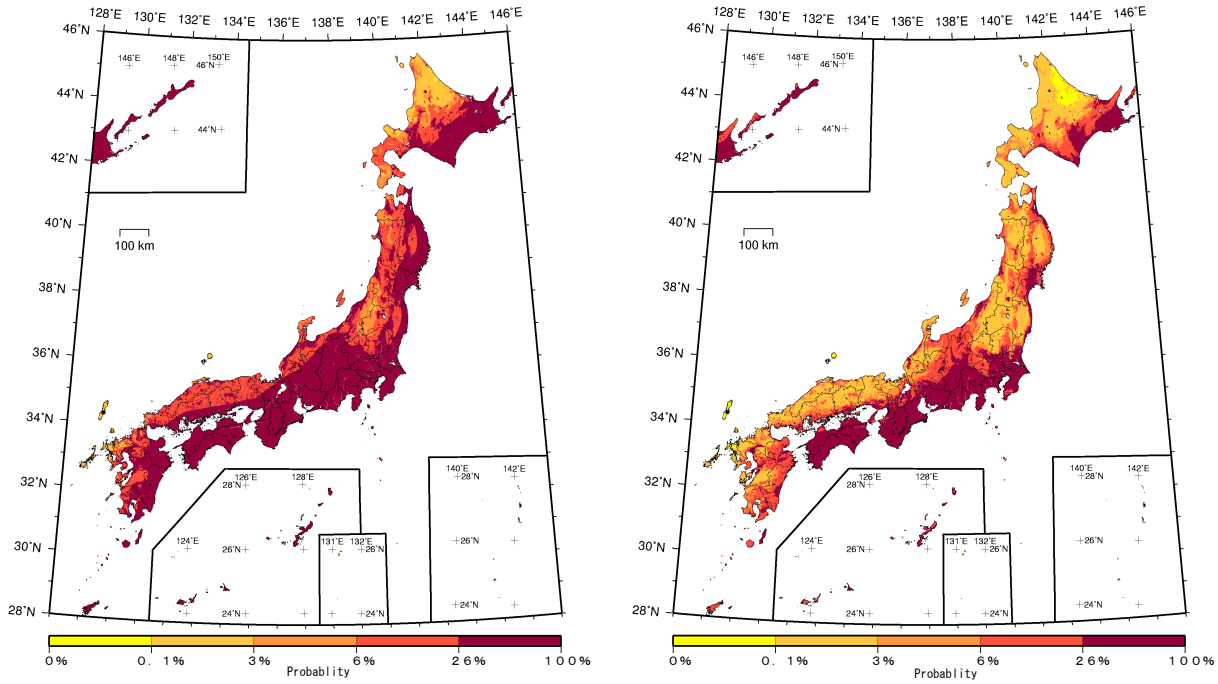
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A Appendix Figures and Tables



(A) Seismic Intensity ≥ 4.5 **(B)** Seismic Intensity ≥ 5

Figure A.1: Earthquake Hazard Map. The maps show the estimated probability of occurrence of a given seismic intensity at each location over the next 30 years, as assessed in 2010. Panel A uses an intensity of 4.5 and Panel B uses an intensity of 5. Source: Headquarters for Earthquake Research Promotion (2010).

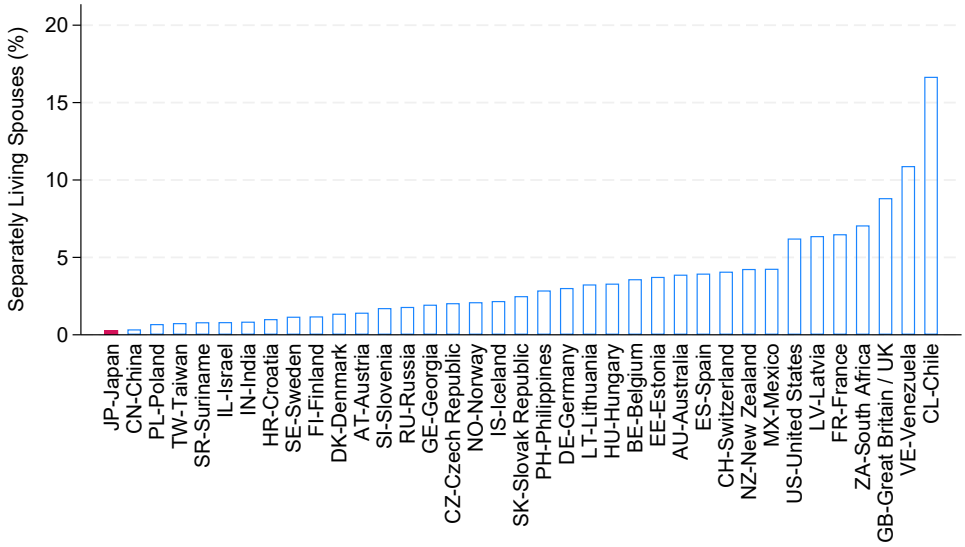


Figure A.2: Percentage of Married Couples Living Separately across Countries. Source: ISSP Research Group (2017)

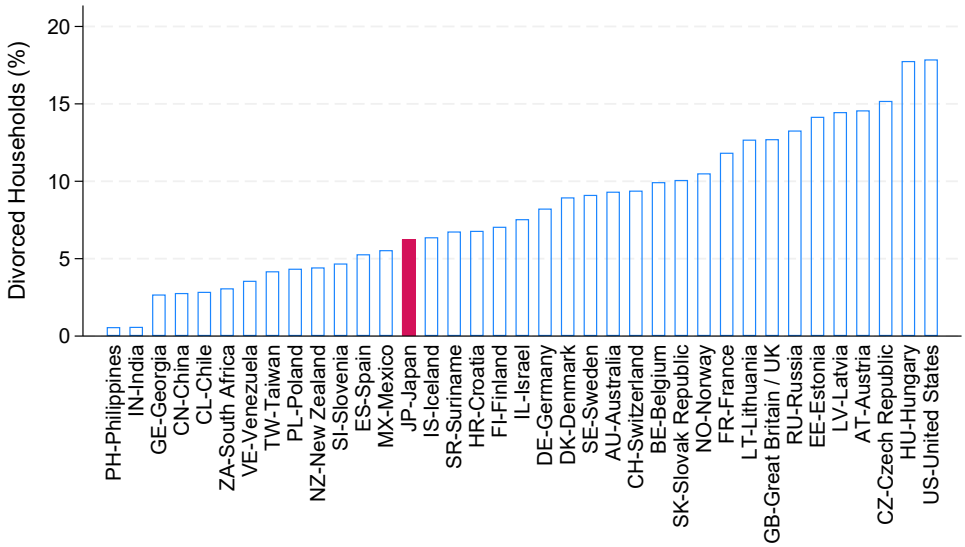
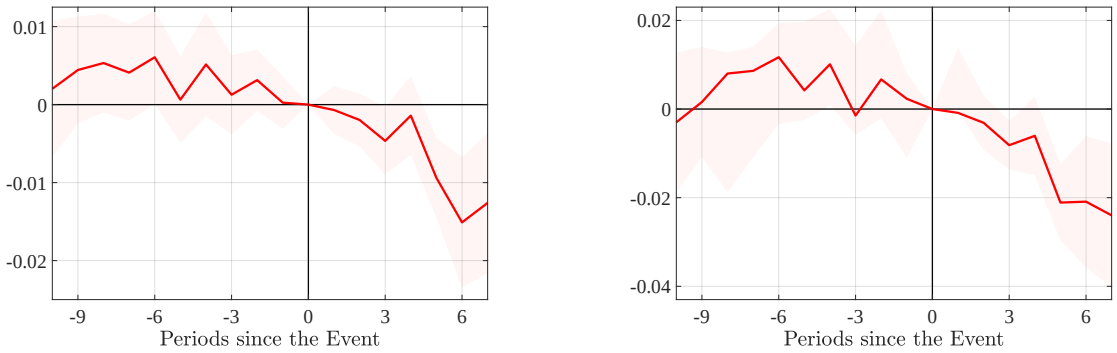


Figure A.3: Percentage of Divorced Households in the Population across Countries. Source: ISSP Research Group (2017)



(A) Treatment: seismic scale ≥ 4.5 **(B)** Treatment: seismic scale ≥ 5

Figure A.4: Dynamic Effect of the Earthquake on Divorce (Baseline 2011). The figure shows estimates of the impact of the earthquake on divorce, with 2011 as the base year, using equation (2) and based on the LSN2001 dataset. The red solid lines show the coefficients of the interaction terms with year dummies. The shaded areas indicate 90% confidence intervals. Standard errors are clustered at the household level.

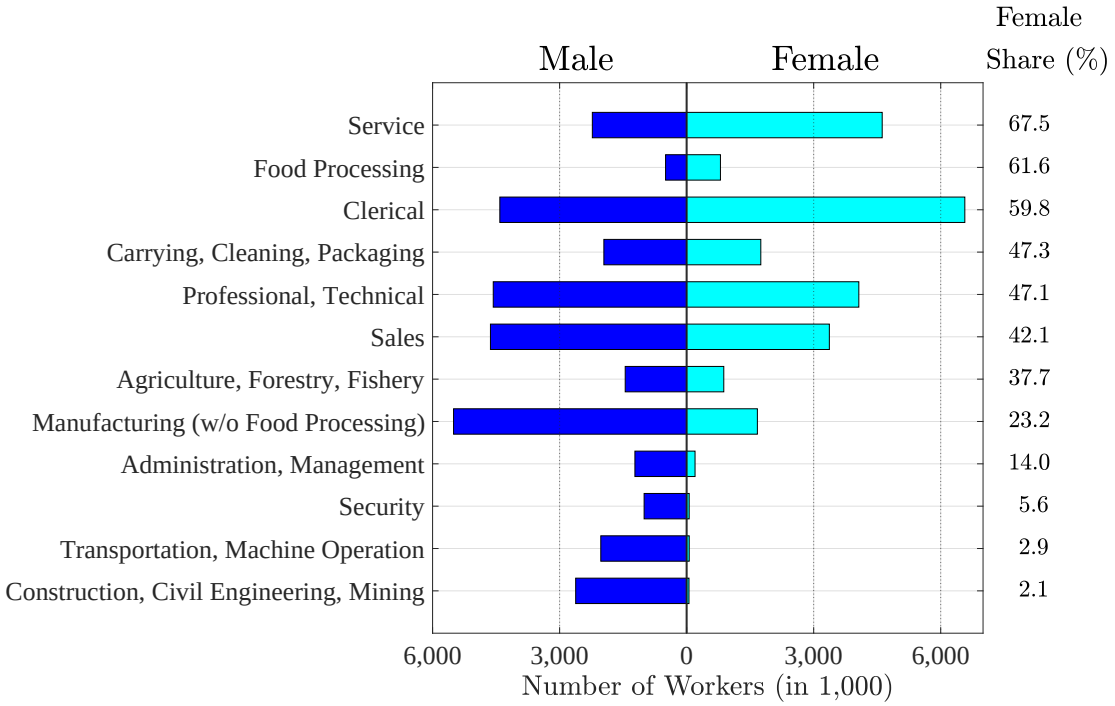
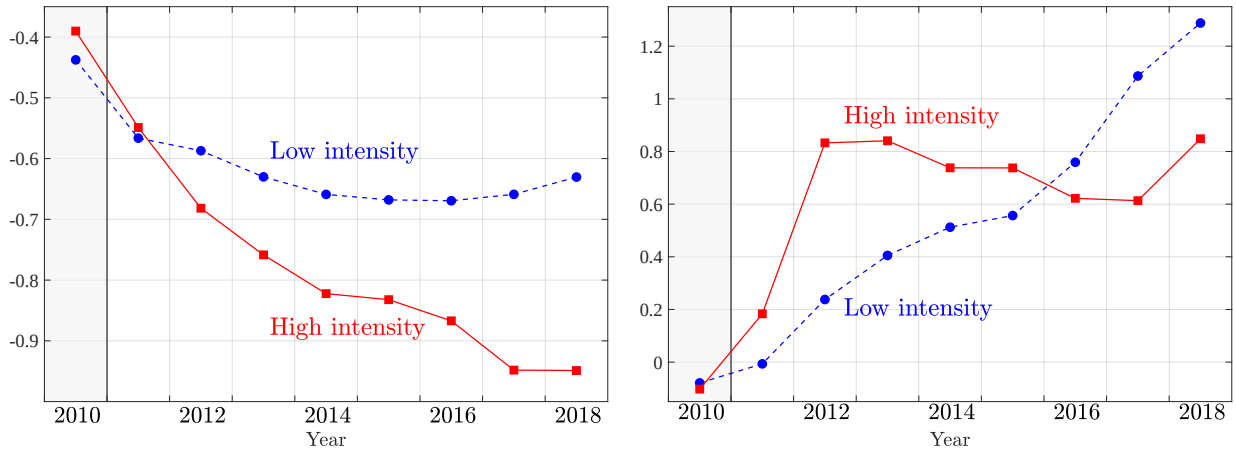


Figure A.5: Number of Employees by Gender in Major Occupations (year 2010). Food processing is separated from general manufacturing for illustration purposes, see text. Occupations are ordered by the proportion of female workers in each occupation, shown on the right axis. Source: Census 2010.



(A) Female-Dominated Jobs

(B) Male-Dominated Jobs

Figure A.6: Job Finding Rate by Occupation. The figure plots the number of job openings per job seeker from 2010 to 2018. Panels A and B show the trend for female-dominated and male-dominated occupations, respectively, relative to gender-neutral occupations. We define a job as female-dominated (male-dominated) if the share of female (male) workers in the total number of workers in that occupation in 2010 exceeds 60%, and consider the rest as gender-neutral occupations. The prefectures of Fukushima, Iwate and Miyagi are the high-seismic intensity areas. Source: Report on Employment Service, Ministry of Health, Labour and Welfare, and Census 2010.

Table A.1: Seismic Intensity Scale

Seismic Intensity	Human Perception and Reaction	Indoor Situation	Outdoor Situation
1	Felt slightly by some people keeping quiet in buildings.	–	–
2	Felt by many people keeping quiet in buildings. Some people may be awoken.	Hanging objects such as lamps swing slightly.	–
3	Felt by most people in buildings. Felt by some people walking. Many people are awoken.	Dishes in cupboards may rattle.	Electric wires swing slightly.
4	Most people are startled. Felt by most people walking. Most people are awoken.	Hanging objects such as lamps swing significantly, and dishes in cupboards rattle. Unstable ornaments may fall.	Electric wires swing significantly. Those driving vehicles may notice the tremor.
4.5-5	Many people are frightened and feel the need to hold onto something stable.	Hanging objects such as lamps swing violently. Dishes in cupboards and items on bookshelves may fall. Many unstable ornaments fall. Unsecured furniture may move, and unstable furniture may topple over.	In some cases, windows may break and fall. People notice electricity poles moving. Roads may sustain damage.
5-5.5	Many people find it hard to move; walking is difficult without holding onto something stable.	Dishes in cupboards and items on bookshelves are more likely to fall. TVs may fall from their stands, and unsecured furniture may topple over.	Windows may break and fall, unreinforced concrete-block walls may collapse, poorly installed vending machines may topple over, automobiles may stop due to the difficulty of continued movement.
5.5-6	It is difficult to remain standing.	Many unsecured furniture moves and may topple over. Doors may become wedged shut.	Wall tiles and windows may sustain damage and fall.
6-6.5	It is impossible to remain standing or move without crawling. People may be thrown through the air.	Most unsecured furniture moves, and is more likely to topple over.	Wall tiles and windows are more likely to break and fall. Most unreinforced concrete-block walls collapse.
6.5+		Most unsecured furniture moves and topples over, or may even be thrown through the air.	Wall tiles and windows are even more likely to break and fall. Reinforced concrete-block walls may collapse.

Note: The table summarizes how each seismic intensity level maps to the human perception, indoor and outdoor situation, and damage. Source: Japan Meteorological Agency (https://www.jma.go.jp/jma/en/Activities/inttable.html#rc)

Table A.2: Summary Statistics (JPSC, Pre-Treatment)

Variable	mean	s.d.	observations	Earthquake Intensity High	Earthquake Intensity Low
Divorce (by family type, %)					
with young child	1.1	10.7	1,653	1.2	1.1
with old child	0.7	8.2	735	1.3	0.4
with no child	1.3	11.6	441	1.2	1.5
Number of children	1.9	0.8	1,653	1.9	1.9
Grandparent(s) cohabiting (%)	20.2	40.2	1,653	22.3	19.1
Female workers (%)					
primary sector	1.6	12.6	804	1.8	1.7
secondary sector	19.6	39.7	804	27.1	16.6
tertiary sector	78.7	40.9	804	71.2	81.8
Male workers (%)					
primary sector	1.8	13.3	1,608	1.8	1.9
secondary sector	43.1	49.5	1,608	34.8	46.5
tertiary sector	54.9	49.7	1,608	62.9	51.5

Note: The table shows the summary statistics of the JPSC sample. The high seismic intensity area corresponds to any region that has experienced a seismic intensity greater than or equal to 4.5. See Section 2.2 for the sample selection.

Table A.3: Effect of the Earthquake on Divorce (Different Specifications)

	Treat: seismic intensity $\geq$ 4.5		**Treat: seismic intensity $\geq$ 5**	
	(1)	(2)	(3)	(4)
	Logit	**Dummy**	**Logit**	**Dummy**
A: Short run (–2014)				
Treat×*Post*	−0.197***	−0.003**	−0.217*	−0.004*
	(0.064)	(0.002)	(0.114)	(0.003)
Observations	258,991	258,991	258,991	258,991
# households	35,275	35,275	35,275	35,275
B: Long run (–2018)				
Treat×*Post*	−0.209***	−0.004**	−0.280***	−0.007**
	(0.055)	(0.002)	(0.099)	(0.003)
Observations	365,863	365,863	365,863	365,863
# households	35,275	35,275	35,275	35,275

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows the impact of the earthquake on divorce using equation (1) and the LSN2001 dataset. Panels A and B refer to the short- and long-run effects up to 3 and 7 years after the earthquake, respectively. We use a seismic intensity of 4.5 and 5 as thresholds to define the treatment group. All specifications include year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. The specification "Logit" (columns 1 and 3) refers to a logit estimation. In the specification "Dummy" (columns 2 and 4), we use a binary variable as a treatment variable instead of the kinked treatment variable. In columns (2) and (4), we include household fixed effects. Standard errors clustered at the household level are reported in parentheses.

Table A.4: Effect of the Earthquake on Income (Seismic Intensity Cutoff of 5)

	All Households			Dual Earners		Single Earners
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Female earnings	Male earnings	Total income	Female earnings	Male earnings	Male earnings
A: Short run (–2014)						
Treat×*Post*	−0.109	−0.270	−0.305	−0.174***	0.243**	−0.731
	(0.039)	(0.327)	(0.337)	(0.058)	(0.118)	(0.654)
Observations	103,669	103,669	102,796	45,251	45,251	55,267
# households	30,854	30,854	30,735	13,243	13,243	16,406
B: Long run (–2018)						
Treat×*Post*	−0.143**	−0.191	−0.247	−0.230***	0.143	−0.501
	(0.038)	(0.275)	(0.289)	(0.058)	(0.092)	(0.543)
Observations	196,018	196,018	189,271	84,743	84,743	104,573
# households	31,580	31,580	31,456	13,420	13,420	16,673

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on income using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. Income information, measured in millions of yen, is available for 2005, 2008, and each year from 2013. We define dual-earner couples as those in which the husband works full time and the wife is employed in 2008, the most recent pre-earthquake year for which income information is available. Standard errors clustered at the household level are reported in parentheses.

Table A.5: Effect of the Earthquake on Labor Margins of Female Workers

	Treat: seismic intensity $\geq$ 4.5		**Treat: seismic intensity $\geq$ 5**	
	(1)	(2)	(3)	(4)
Dependent variable	Employment	Hours	Employment	Hours
A: Short run (–2014)				
Treat×*Post*	−0.015*	−0.717**	−0.066*	−1.711***
	(0.008)	(0.338)	(0.014)	(0.605)
Observations	120,022	51,923	120,022	51,923
# households	31,879	18,557	31,879	18,557
B: Long run (–2018)				
Treat×*Post*	−0.014*	−0.803***	−0.071***	−2.091***
	(0.008)	(0.312)	(0.014)	(0.557)
Observations	211,797	75,255	211,797	75,255
# households	32,422	23,941	32,422	23,941

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on labor margins of female workers using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 4.5 and 5 as thresholds to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. Hours worked, available for 2005, 2008, 2011, 2013, and 2017, are measured in four categories: less than 20 hours, 20-40 hours, 40-60 hours, and more than 60 hours. Columns (2) and (4) refer to the hours worked conditional on being employed. Standard errors clustered at the household level are reported in parentheses.

Table A.6: Effect of the Earthquake on Job Search of Married Female Workers

	Treat: seismic intensity $\geq$ 4.5		**Treat: seismic intensity $\geq$ 5**	
	(1)	(2)	(3)	(4)
Dependent variable	through 2012	through 2013	through 2012	through 2013
Treat×*Post*	0.011**	0.007*	0.020**	0.013*
	(0.005)	(0.004)	(0.009)	(0.007)
Observations	145,025	163,368	145,025	163,368
# households	21,131	21,131	21,131	21,131

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on labor margins and job search behavior of married female workers using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 4.5 and 5 as thresholds to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. Estimates are based on the sample of households that were a dual-earner couple in at least one period prior to the earthquake. Standard errors clustered at the household level are reported in parentheses.

Table A.7: Sectoral Migration of Husbands

	Primary Sector		**Secondary Sector**		**Tertiary Sector**	
	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All husbands	With a young child	All husbands	With a young child	All husbands	With a young child
Treat×*Post*	−0.003	−0.002	0.037**	0.042	−0.032**	−0.031
	(0.004)	(0.004)	(0.017)	(0.029)	(0.018)	(0.030)
Observations	11,078	4,429	11,078	4,429	11,078	4,429
# households	1,295	705	1,295	705	1,295	705

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on the sectors in which married male workers work using equation (1) based on the JPSC dataset. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. The results in columns (1), (3) and (5) refer to the sample of all husbands, and those in columns (2), (4) and (6) refer to the sample of husbands with a child under the age of ten in 2011. Standard errors clustered at the household level are reported in parentheses.

Table A.8: Effect of the Earthquake on Labor Margins of Male Workers

	Treat: seismic intensity $\geq$ 4.5		**Treat: seismic intensity $\geq$ 5**	
	(1)	(2)	(3)	(4)
Dependent variable	Employment	Hours	Employment	Hours
A: Short run (–2014)				
Treat×*Post*	0.001	0.189	0.004	0.680*
	(0.001)	(0.216)	(0.003)	(0.389)
Observations	119,521	96,043	119,521	96,043
# households	31,753	31,614	31,753	31,614
B: Long run (–2018)				
Treat×*Post*	0.000	−0.052	0.002	0.440
	(0.001)	(0.190)	(0.003)	(0.342)
Observations	210,680	118,207	210,680	118,207
# households	32,218	32,187	32,218	32,187

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on labor margins of male workers using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 4.5 and 5 as thresholds to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. Hours worked, available for 2005, 2008, 2011, 2013, and 2017, are measured in four categories: less than 20 hours, 20-40 hours, 40-60 hours, and more than 60 hours. Columns (2) and (4) refer to the hours worked conditional on being employed. Standard errors clustered at the household level are reported in parentheses.

Table A.9: Interaction Effect of the Earthquake and Female Earnings on Male Earnings

	Treat: seismic intensity $\geq$ 4.5	**Treat: seismic intensity $\geq$ 5**
Dependent variable	Male Earnings	Male Earnings
A: Short run (–2014)		
Treat×*Post*×*Female Earnings*	−0.802***	−0.702**
	(0.222)	(0.344)
Treat×*Post*	1.561***	1.322*
	(0.471)	(0.725)
Treat×*Female Earnings*	−1.274***	−1.300**
	(0.439)	(0.591)
Post×*Female Earnings*	0.473***	0.454***
	(0.137)	(0.172)
Female Earnings	1.522***	1.419***
	(0.259)	(0.274)
Observations	103,669	103,669
# households	30,854	30,854
B: Long run (–2018)		
Treat×*Post*×*Female Earnings*	−0.532**	−0.396
	(0.212)	(0.330)
Treat×*Post*	1.491**	1.220
	(0.610)	(0.818)
Treat×*Female Earnings*	−1.152**	−1.158**
	(0.544)	(0.582)
Post×*Female Earnings*	0.273*	0.258
	(0.142)	(0.169)
Female Earnings	1.438***	1.328***
	(0.363)	(0.353)
Observations	196,018	196,018
# households	31,580	31,580

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the triple interaction term *Treat*×*Post*×*Female Earnings* on *Male Earnings* using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 4.5 and 5 as thresholds to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. Standard errors clustered at the household level are reported in parentheses.

Table A.10: Heterogeneous Bundling Effect by Pre-Earthquake Household Income

	Treat: seismic intensity $\geq$ 4.5			Treat: seismic intensity $\geq$ 5		
	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All	High Income	Low Income	All	High Income	Low Income
Treat×*Post*	−0.007***	−0.001	−0.011***	−0.016***	−0.009	−0.024***
	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.007)
Observations	312,491	155,592	156,899	312,491	155,592	156,899
# households	29,726	14,589	15,137	29,726	14,589	15,137

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on divorce using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 4.5 and 5 as thresholds to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for number of children, and a control for whether a grandparent lives in the same household. We split the sample at the median household income in 2008, the latest pre-earthquake year with income information. Standard errors clustered at the household level are reported in parentheses.

B Discussion of Alternative Explanations

We discuss the alternative mechanisms considered in Section 4.3 in more detail.

Family Ties. The earthquake was not only a major economic shock, but also a traumatic event that may have acted as a love shock, leading to fewer divorces by strengthening family ties. However, this psychological explanation is contradicted by several pieces of evidence.

First, the love shock is likely to be uniform across individuals, which cannot explain the heterogeneity in bundling effects across income types observed in Table 4. In Table 8, we also find no significant effect of the earthquake shock on marital stability for families with older children or for couples without children.

While we find no evidence of a general positive "love shock," it is still possible that the preference shock interacts with the presence of a child and the child's age. That is, only parents with a young child may not want to subject their children to another traumatic event—parental divorce—after they have already suffered from the earthquake. To test this particular channel, we analyze the survey question "(w)as the family tie strengthened thanks to the presence of the child?" ("0 Does not apply" or "1 Applies") asked in the LSN2001 dataset. We use this dummy variable as our dependent variable in column (1) of Table B.1. If children were the reason for not separating after the earthquake, we would expect to find a positive effect of the earthquake on this outcome variable. In contrast, we

Table B.1: Family Ties

	(1) Family Ties	(2) Marriage Satisfaction	(3) Additional Births	(4) Mental Health
Treat×*Post*	−0.015**	−0.066	−0.003*	−0.361
	(0.006)	(0.112)	(0.002)	(0.600)
Observations	159,975	3,743	296.580	4,546
# households	35,195	580	35,195	711

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on several variables related to the strength of family ties using equation (1). We use a seismic intensity of 4.5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for the number of children and for whether the grandparents live in the same household. Column (1) is based on the question in the LSN2001 dataset, "(w)as the family tie strengthened thanks to the presence of the child?" and the possible responses are "0 Does not apply" or "1 Does Apply". In column (2), the dependent variable measures marriage satisfaction based on the question in the JPSC dataset, "(a)re you satisfied with your marriage to your husband?" on a scale from "1 Not at all" to "5 Very much". Column (3) reports the impact of the earthquake on the probability of having an additional child based on the LSN2001 dataset. Column (4) is based on a module on mental health in the JPSC, which consists of 13 questions about the respondent's mental state in the past week. Each is measured on a scale from 1 to 4, with a higher score corresponding to poorer mental health. The dependent variable is the sum of these 13 variables. Standard errors clustered at the household level are reported in parentheses.

find a negative and significant effect. Thus, the evidence does not support the idea of a change in family ties being the main driver of our results.

To examine the strength of the marital bond, we also analyze a question about marital satisfaction, "(a)re you satisfied with your marriage to your husband?" asked in the JPSC dataset. We code the responses so that a higher score corresponds to higher marital satisfaction (from "1 Not at all" to 5 "Very much"). If family ties changed differently for households that were more or less affected by the earthquake, we would expect a relative change in responses to this question. However, column (2) of Table B.1 shows that marriage satisfaction did not change significantly for the treated households relative to the control group.

Next, we estimate the effect of the earthquake on higher order fertility based on the LSN2001 dataset. In column (3) of Table B.1, we show that the probability of having an additional child after the earthquake is lower in the treatment group than in the control group. This finding also implies that our divorce results are not driven by the pressure of the biological clock, which may induce fertile women to avoid divorce after a negative labor demand shock (Keller and Utar, 2022). These findings can be reconciled with our proposed mechanism of women staying in marriages even with lower match quality for economic reasons, but not with the idea of positive love shocks.

Table B.2: The Impact of the Earthquake on Insurance

	Fire Insurance		Earthquake Insurance		Life Insurance	
	(1)	(2)	(3)	(4)	(5)	(6)
	Furniture	Buildings	Furniture	Buildings	Husband	Wife
Treat×*Post*	0.109	−0.048	0.074	−0.041	−0.040	0.062
	(0.103)	(0.087)	(0.121)	(0.102)	(0.056)	(0.068)
Observations	2,695	2,853	2,601	2,692	2,838	2,793
# households	391	407	379	386	409	400

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on insurance products owned by households with young children using equation (1) based on the JHPS/KHPS dataset. We use a seismic intensity of 4.5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for the number of children and for whether the grandparents live in the same household. Standard errors clustered at the household level are reported in parentheses.

Finally, we find no statistically significant effect on mental health (column 4). Thus, it is unlikely that the divorce rate is reduced by worsening mental health.

Value of Insurance. Given that the earthquake was unpredictable (Knightian uncertainty), people may have updated their expectations after the shock. In particular, with the possibility of a deadly natural disaster added to the probability space, they may have begun to value insurance more after the earthquake.

While we cannot directly observe changes in expectations, we can examine the impact of the earthquake on the probability of owning various insurance products. For this purpose, we turn to an additional Japanese household dataset, the Japan/Keio Household Panel Survey (JHPS/KHPS). This household panel dataset started in 2004 (KHPS) / 2009 (JHPS) and interviews about 7,000 households annually. The dataset provides information on the exact household composition and marital status in each year, which makes it possible to specify the sample in the same way as for the LSN2001 and the JPSC and to use the same control variables as before. The JHPS/KHPS asks detailed questions on the various insurance products owned by the household. The questions have been asked since 2012, but households are also asked for the year in which the specific insurance was purchased, allowing us to include the pre-earthquake period in the analysis. As in the case of LSN2001, we use the years 2005 to 2018 and include households where the parents were married in 2005 and had at least one child under the age of 10 in each sample period.

Table B.2 shows the impact of the earthquake on the probability of owning various

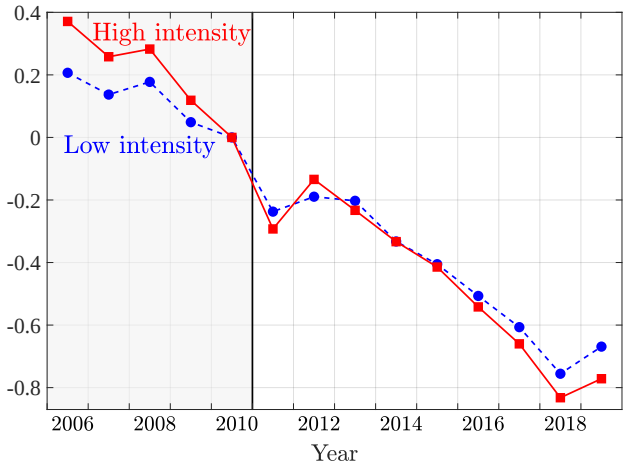


Figure B.1: Marriage Rates at the Prefecture Level. The figure shows the number of new marriages per 1,000 population, relative to 2010. The time of the earthquake is indicated by the vertical line. Source: Vital Statistics from the Ministry of Health, Labour and Welfare, population estimates from the Statistics Bureau, the Ministry of Internal Affairs and Communications.

insurance products.[1] It provides evidence for fire insurance (furniture and buildings), earthquake insurance (furniture and buildings), and life insurance (for husband and wife). We do not find any significant effect. This suggests that households that were more affected by the earthquake did not change their insurance purchasing behavior after the earthquake relative to households that were less affected.[2]

We also look at marriage rates to see if they increased in the treated areas compared to the control areas. In Japan, couples typically marry before having a child. Thus, a relative increase in marriage in the treatment areas would indicate an increase in the value of family insurance, but would not be expected based on the channel we propose, which is based on the presence of children. Since we do not have good micro-level data to analyze marriage behavior, we turn to prefecture-level data and divide the prefectures into treatment and control groups using a seismic scale threshold of 4.5. Figure B.1 does not show such an increase in marriage rates in the treated areas.

Finally, Hanaoka et al. (2018) find no evidence of increased risk aversion, which could lead to a higher value of insurance, due to the earthquake shock.

Housing Wealth. The earthquake caused major damage to many residential buildings, significantly reducing the wealth of many households. It is theoretically and empirically ambiguous how a decline in housing wealth affects divorce (e.g., Rainer and Smith, 2010; Farnham et al., 2011). On the one hand, a decline in house prices means a loss of equity for

[1]The table is based on the period 2005-2018. The results for the short term (up to 2014) are very similar.
[2]Note that we do not control for potential changes on the supply side.

Table B.3: Divorce and Housing Wealth

	Add Control		Drop Sample	
	(1)	(2)	(3)	(4)
	House Price	Destroyed Houses	Seismic Intensity ≥ 6	Destroyed Houses $\geq 0.01\%$
Treat×*Post*	−0.007***	−0.008***	−0.008***	−0.007*
	(0.003)	(0.003)	(0.003)	(0.004)
Observations	340,443	365,863	364,008	344,220
# households	34,726	35,275	35,188	33,470

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1. The table shows estimates of the impact of the earthquake on divorce using equation (1) based on the LSN2001 dataset. We use a seismic intensity of 4.5 as the threshold to define the treatment group. All specifications include household fixed effects, year fixed effects, a control for the number of children and for whether the grandparents live in the same household. Column (1) controls for housing values. Column (2) controls for the number of completely destroyed houses. Column (3) excludes areas with a seismic intensity of 6 or higher. Column (4) excludes areas where at least 0.01% of all buildings were completely destroyed. Standard errors clustered at the household level are reported in parentheses.

homeowners, which makes it more difficult to afford two separate homes after a divorce, thereby reducing divorce rates. On the other hand, it could lead to more affordable rents, which in turn would make it easier to split a family in two after a divorce. In addition, a decline in housing wealth could increase financial stress, potentially increasing the likelihood of divorce.

Empirically, using household-level data for the United Kingdom, Rainer and Smith (2010) find that a negative house price shock is associated with a significant increase in the probability of divorce, and the destabilizing effect is particularly strong for couples with young children. In contrast, Farnham et al. (2011) find that declining house prices reduce the divorce risk of owners in the United States using an MSA-level dataset and using education as a proxy for homeownership. Given the ambiguity in both the theoretical predictions and the empirical evidence, it is a priori unclear how a change in housing wealth might affect marital stability in our context.

We provide suggestive evidence that the housing wealth channel is not the main channel driving our result (Table B.3). First, we merge municipal-level data on property values provided by the Ministry of Land, Infrastructure, Transport and Tourism into our LSN2001 dataset. We add these housing values as a control variable to our baseline model. The results are unaffected when we control for changes in property values over time (column 1 of Table B.3). Next, we add information on the number of damaged houses

per municipality to the dataset, based on administrative damage reports at the location level. In column (2) we control for the number of completely destroyed houses. Again, the results hardly change. An alternative way of accounting for housing damage is to exclude the most affected areas from the sample. We do this in columns (3) and (4). In column (3), we exclude areas with very high seismic intensity, namely those with a seismic intensity of 6 or higher, where property damage is most severe (see Table A.1). In column (4), we drop areas where at least 0.01% of the buildings were completely destroyed (1 out of 10,000 houses). Again, the results are robust. Based on these results, we find no evidence that changes in housing wealth are the main driver of the decline in divorce.

C Theory Appendix

C.1 General Formulation of the Model

In this section we present the general formulation of the model presented in Section 5. The model in the main text is a special case suitable for analyzing the effect of the labor market shock and developing economic intuition.

Environment. There is a married couple with a child. The preferences for each spouse $i \in \{w, h\}$, where w is the wife and h is the husband, are represented by a utility function, $u(c_i, \ell_i)$, where c is consumption good and ℓ is leisure. If the couple stays married, the individual utility is given by $u(c_i, \ell_i) + \theta_i$, where θ_i represents match quality that is uncertain. We assume that these nonpecuniary benefits of marriage are additively separable (Weiss and Willis, 1997).

The model has two periods, $t = 1, 2$. At the beginning of period 1, the match quality θ_i is realized. Given this, the couple decides whether to divorce. In period 2, they make decisions about intra-household allocations jointly if they stay married (M), or separately if they divorce (D).

Spouses enter the economy with exogenous income levels $(y_w, y_h) \in \mathbb{R}^2_+$. We add the employment decision $e_i \in \{0, 1\}$ and the job switching decision $s_i \in \{0, 1\}$ to the model described in Section 5.1. They are also each endowed with 1 unit of time. Assume that having a child requires a fixed parental care time $\bar{n} \geq 0$. One spends ε units of time supplying market labor and κ units of time changing jobs.

Match quality is the only uncertainty in the model. The model can be easily extended to include income or labor market uncertainty. The savings decision can also be incorporated by introducing an intertemporal allocation stage at the beginning, where the couple decides on the consumption-savings decision before drawing a new value

of match quality in period 1, similar to the general three-stage formulation discussed in Chiappori and Mazzocco (2017).

Period 2: Intra-Household Allocation Stage. The problem of a divorcee in period 2 can be written as follows: for $i \in \{w,h\}$,

$$\begin{aligned} V_i^D(y_i) = \max_{\{c_i,\ell_i,n_i,e_i,s_i\}} \quad & u(c_i,\ell_i), \\ \text{s.t.} \quad & c_i \leq [(1-s_i)\,y_i + s_i y_i']\,e_i, \\ & \ell_i + n_i \leq 1 - e_i\varepsilon - s_i\kappa, \\ & n_i = \begin{cases} \bar{n} & \text{if } i = w, \\ 0 & \text{if } i = h, \end{cases} \end{aligned} \tag{C.1}$$

where n_i is the childcare time and y_i' is the income when changing jobs for $i \in \{w,h\}$. The first constraint is the budget constraint, and the second is the time constraint. The wife gets custody of the child, which is represented by the third constraint.

Next, the problem of the married couple (9) is generalized. Denote by μ_i the decision power for $i \in \{w,h\}$ and write $\boldsymbol{\mu} = \{\mu_w, \mu_h\}$. In Section 5.1, we considered the case in which $\mu_w = \mu$ and $\mu_h = 1-\mu$. Define the state variable $x \equiv \{y_w, y_h, \theta_w, \theta_h\}$. The problem of the married couple is

$$\begin{aligned} V^M(x,\boldsymbol{\mu}) = \max_{\{c_i,\ell_i,n_i,e_i,s_i\}} \quad & \sum_{i\in\{w,h\}} \mu_i\,[u(c_i,\ell_i) + \theta_i], \\ \text{s.t.} \quad & \sum_{i\in\{w,h\}} c_i \leq \sum_{i\in\{w,h\}} [(1-s_i)\,y_i + s_i y_i']\,e_i, \\ & l_i + n_i \leq 1 - e_i\varepsilon - s_i\kappa, \text{ for } i \in \{w,h\}, \\ & \sum_{i\in\{w,h\}} n_i = \bar{n}. \end{aligned} \tag{C.2}$$

The last constraint captures the fact that when spouses stay together, they share childcare time. The resource share is the economic benefit of marriage in the model.

The solution to this problem is denoted by $\{c_i^*, \ell_i^*, n_i^*, e_i^*, s_i^*\}_{i\in\{w,h\}}$. Similar to equation (10), we have the value of marriage for each $i \in \{w,h\}$:

$$V_i^M(x,\boldsymbol{\mu}) = u(c_i^*(x,\boldsymbol{\mu}), \ell_i^*(x,\boldsymbol{\mu})) + \theta_i. \tag{C.3}$$

Period 1: Divorce Decision Stage. The couple observes the realization of the state x and decides whether to divorce. We assume unilateral divorce. The problem of divorce is thus

an individual problem such that for $i \in \{w,h\}$,

$$V_i(x,\boldsymbol{\mu}) = \max\left\{V_i^M(x,\boldsymbol{\mu}), V_i^D(y_i)\right\},$$

where V_i is the individual indirect utility.

Alternative Formulation and Renegotiation. In Section 5.3 we discussed the possibility of renegotiation. For this purpose, we now combine the two stages. Given the value of divorce $V_i^D(\cdot)$ in (C.1), we can write

$$\begin{aligned} V^M(x,\boldsymbol{\mu}) = \max_{\{c_i,\ell_i,n_i,e_i,s_i\}} \quad & \sum_{i\in\{w,h\}} \mu_i\left[u(c_i,\ell_i)+\theta_i\right], \\ \text{s.t.} \quad & \sum_{i\in\{w,h\}} c_i \leq \sum_{i\in\{w,h\}} \left[(1-s_i)\,y_i + s_i y_i'\right] e_i, \\ & \ell_i + n_i \leq 1 - e_i\varepsilon - s_i\kappa, \text{ for } i\in\{w,h\}, \\ & \sum_{i\in\{w,h\}} n_i = \bar{n}, \\ & u(c_i,\ell_i)+\theta_i \geq V_i^D(y_i), \text{ for } i\in\{w,h\}. \end{aligned} \tag{C.4}$$

The last constraint is the participation constraint PC_i for each member $i \in \{w,h\}$.

There are three possibilities. First, both participation constraints are slack at the optimum. In this case, problem (C.4) boils down to problem (C.2). Second, there is no feasible allocation that satisfies both participation constraints at the same time. That is, there is no solution to problem (C.4). In this case, the couple decides to divorce and solves problem (C.1) separately. Finally, one participation constraint is slack, while the other is violated at the optimum. In this case, renegotiation of decision power takes place.

We are particularly interested in the case where PC_w is slack while PC_h is violated due to the labor market shock associated with the earthquake. In this case, the decision power is renegotiated and changes to $\hat{\boldsymbol{\mu}}$, which makes the husband indifferent between being

single or married (Ligon et al., 2002). That is,

$$
\begin{aligned}
V^M(x,\hat{\boldsymbol{\mu}}) = \quad & \max_{\{c_i,\ell_i,n_i,e_i,s_i\}} \quad \sum_{i\in\{w,h\}} \hat{\mu}_i \left[u(c_i,\ell_i)+\theta_i\right], \\
& \text{s.t.} \qquad \sum_{i\in\{w,h\}} c_i \leq \sum_{i\in\{w,h\}} \left[(1-s_i)\,y_i + s_i y_i'\right] e_i, \\
& \qquad\qquad \ell_i + n_i \leq 1 - e_i\varepsilon - s_i\kappa, \text{ for } i\in\{w,h\}, \\
& \qquad\qquad \sum_{i\in\{w,h\}} n_i = \bar{n}, \\
& \qquad\qquad V_h^M(x,\hat{\boldsymbol{\mu}}) = V_h^D(y_h),
\end{aligned}
\tag{C.5}
$$

where the value of marriage in the last constraint is given by equation (C.3).

The resulting $\hat{\mu}_h$ is given by $\hat{\mu}_h = \mu_h + \lambda_h$, where $\lambda_h \geq 0$ is the Karush-Kuhn-Tucker (KKT) multiplier on the participation constraint PC_h. To see this, we employ the approach developed by Marcet and Marimon (2011), where problem (C.4) is reformulated as

$$
\begin{aligned}
V^M(x,\boldsymbol{\mu}) = \quad & \max_{\{c_i,\ell_i,n_i,e_i,s_i\}} \quad \sum_{i\in\{w,h\}} \left\{\mu_i\left[u(c_i,\ell_i)+\theta_i\right] + \lambda_i\left[u(c_i,\ell_i)+\theta_i - V_i^D(y_i)\right]\right\}, \\
& \text{s.t.} \qquad \sum_{i\in\{w,h\}} c_i \leq \sum_{i\in\{w,h\}} \left[(1-s_i)\,y_i + s_i y_i'\right] e_i, \\
& \qquad\qquad \ell_i + n_i \leq 1 - e_i\varepsilon - s_i\kappa, \text{ for } i\in\{w,h\}, \\
& \qquad\qquad \sum_{i\in\{w,h\}} n_i = \bar{n},
\end{aligned}
\tag{C.6}
$$

where $\lambda_i \geq 0$ is the KKT multiplier on the participation constraint PC_i. Using the above notation, the objective function can be written as

$$
\sum_{i\in\{w,h\}} \left\{\hat{\mu}_i\left[u(c_i,\ell_i)+\theta_i\right] - \lambda_i V_i^D(y_i)\right\},
$$

where $\hat{\mu}_i = \mu_i + \lambda_i$, for $i\in\{w,h\}$.

In the case where both participation constraints are slack at the optimum, we have $\lambda_i = 0$ and $\hat{\mu}_i = \mu_i$, and thus the objective function boils down to the usual objective, i.e.,

$$
\sum_{i\in\{w,h\}} \mu_i\left[u(c_i,\ell_i)+\theta_i\right].
$$

Now consider the case where PC_w is slack while PC_h is violated. This means $\lambda_w = 0$, which gives $\hat{\mu}_w = \mu_w$, and $\lambda_h > 0$, which gives $\hat{\mu}_h > \mu_h$. Also, at optimum the husband's

participation constraint is satisfied with equality, i.e.,

$$u(c_h(x,\hat{\boldsymbol{\mu}}),\ell_h(x,\hat{\boldsymbol{\mu}}))+\theta_h = V_h^D(y_h).$$

Substituting these results into problem (C.6) yields

$$\begin{aligned} V^M(x,\{\mu_w,\hat{\mu_h}\}) = \max_{\{c_i,\ell_i,n_i,e_i,s_i\}} \quad & \mu_w\left[u(c_w,\ell_w)+\theta_w\right]+\hat{\mu}_h\left[u(c_h,\ell_h)+\theta_h\right], \\ \text{s.t.} \quad & \sum_{i\in\{w,h\}} c_i \le \sum_{i\in\{w,h\}} \left[(1-s_i)y_i+s_i y_i'\right]e_i, \\ & \ell_i+n_i \le 1-e_i\varepsilon-s_i\kappa, \text{ for } i\in\{w,h\}, \\ & \sum_{i\in\{w,h\}} n_i = \bar{n}. \end{aligned}$$

This is similar to the problem of the married couple without participation constraints (C.2), but differs in that it effectively gives the husband a higher Pareto weight $\hat{\mu}_h > \mu_h$. The increase in weight is given by the KKT multiplier on the participation constraint λ_h in the original problem (C.4).

C.2 Proof of Proposition 1

Family Insurance. After the labor market shock, the married couple jointly solves the following Pareto problem with job switching decisions:

$$\begin{cases} \max\limits_{\{c_i,\ell_i,n_i,s_i\}} & \mu\left[\log(c_w)+\log(\ell_w)+\theta_w\right]+(1-\mu)\left[\log(c_h)+\log(\ell_h)+\theta_h\right], \\ \text{s.t.} & c_w+c_h \le s_w y_w'+(1-s_h)y_h+s_h y_h', \\ & \ell_w+n_w \le 1-s_w(\varepsilon+\kappa), \\ & \ell_h+n_h \le 1-\varepsilon-s_h\kappa, \\ & n_w+n_h=\bar{n}. \end{cases}$$

Taking the first-order conditions (FOC) gives

$$\begin{aligned} c_w \quad : \quad & \mu\frac{1}{c_w}+(1-\mu)\frac{-1}{s_w y_w'+(1-s_h)y_h+s_h y_h'-c_w}=0, \\ n_w \quad : \quad & \mu\frac{-1}{1-s_w(\varepsilon+\kappa)-n_w}+(1-\mu)\frac{1}{1-\varepsilon-s_h\kappa-(\bar{n}-n_w)}=0. \end{aligned}$$

After some algebra, we obtain $\{c_w,c_h,\ell_w,\ell_h\}=\{\mu Y,(1-\mu)Y,\mu T,(1-\mu)T\}$, where $Y = s_w y_w'+(1-s_h)y_h+s_h y_h'$ and $T = 2-\bar{n}-s_w(\varepsilon+\kappa)-\varepsilon-s_h\kappa$.

Depending on the job switching decisions, we have four cases for the household resources:

$$(Y,T) = \begin{cases} (y_h, 2-\bar{n}-\varepsilon) & \text{if } s_w = 0 \text{ and } s_h = 0, \\ (y'_h, 2-\bar{n}-\varepsilon-\kappa) & \text{if } s_w = 0 \text{ and } s_h = 1, \\ (y'_w + y_h, 2-\bar{n}-2\varepsilon-\kappa) & \text{if } s_w = 1 \text{ and } s_h = 0, \\ (y'_w + y'_h, 2-\bar{n}-2\varepsilon-2\kappa) & \text{if } s_w = 1 \text{ and } s_h = 1. \end{cases}$$

Note that since $\kappa \leq 1-\bar{n}-\varepsilon$, $T > 0$ in all cases. Given these cases, the couple optimally chooses $(s_w, s_h) = (0,1)$, and thus the family insurance is present, if and only if

$$\begin{aligned} \log(y'_h) + \log(2-\bar{n}-\varepsilon-\kappa) &\geq \log(y_h) + \log(2-\bar{n}-\varepsilon), \\ \log(y'_h) + \log(2-\bar{n}-\varepsilon-\kappa) &\geq \log(y'_w + y_h) + \log(2-\bar{n}-2\varepsilon-\kappa), \text{ and} \\ \log(y'_h) + \log(2-\bar{n}-\varepsilon-\kappa) &\geq \log(y'_w + y'_h) + \log(2-\bar{n}-2\varepsilon-2\kappa). \end{aligned}$$

Using the first condition, we obtain the condition for y'_h:

$$y'_h \geq \frac{2-\bar{n}-\varepsilon}{2-\bar{n}-\varepsilon-\kappa} y_h. \tag{C.7}$$

Using this condition and the other two conditions above, after some algebra, we obtain the condition for y'_w:

$$y'_w \leq \frac{\varepsilon+\kappa}{2-\bar{n}-2\varepsilon-\kappa} y_h. \tag{C.8}$$

If the time cost of market work or job search is sufficiently large, this condition is satisfied. It is also implied that $y'_h \geq y'_w$, which is likely to be satisfied. Under the conditions (C.7-C.8), it is optimal for the couple to choose $(s_w, s_h) = (0,1)$, and thus family insurance is present.

□

Bundling Effects. Using equations (12-13), the probability of divorce decreases after the adverse shock, and thus the bundling effect is present, if

$$\frac{y'_h}{y'_w} > \frac{y_w + y_h}{y_w} \frac{2-\bar{n}-2\varepsilon}{2-\bar{n}-\varepsilon-\kappa} \frac{1-\bar{n}-\varepsilon-\kappa}{1-\bar{n}-\varepsilon}. \tag{C.9}$$

If y'_w is sufficiently low and y'_h is sufficiently high, then this condition is satisfied.

Under the condition (C.8), a sufficient condition for y'_h is

$$y'_h > \frac{(y_w+y_h)y_h}{y_w} \frac{(\varepsilon+\kappa)(2-\bar{n}-2\varepsilon)(1-\bar{n}-\varepsilon-\kappa)}{(2-\bar{n}-2\varepsilon-\kappa)(2-\bar{n}-\varepsilon-\kappa)(1-\bar{n}-\varepsilon)}.$$

Likewise, if the condition (C.7) is satisfied, a sufficient condition for y'_w is

$$y'_w < \frac{y_w y_h}{y_w + y_h} \frac{(2-\bar{n}-\varepsilon)(1-\bar{n}-\varepsilon)}{(2-\bar{n}-2\varepsilon)(1-\bar{n}-\varepsilon-\kappa)}.$$

There is one special case with a clear interpretation. Since $y'_w < y_w$, the condition (C.9) is satisfied if the family insurance is substantial in the sense that

$$\frac{y'_h}{y_w + y_h} \geq \frac{2-\bar{n}-2\varepsilon}{2-\bar{n}-\varepsilon-\kappa} \frac{1-\bar{n}-\varepsilon-\kappa}{1-\bar{n}-\varepsilon}. \tag{C.10}$$

Also, the condition (C.9) is more likely to be satisfied if the job switching cost κ is higher so that the right-hand side of the condition becomes lower.

□

Heterogeneous Bundling Effect across Family Income Types. Consider a single-earner household. We add job switching decisions to the problem (7) before the adverse shock in a stationary environment, where the job opportunity is given by y_w. Solving the problem, we have the value of divorce

$$V_w^D(0) = \log(y_w) + \log(1-\bar{n}-\varepsilon-\kappa).$$

Also, solving the problem (9), the value of marriage for the wife is given by equation (10) with $Y = y_h$ and $T = 2-\bar{n}-\varepsilon$.

Using these expressions and PC_w, the probability of divorce before the earthquake is given by

$$F_\theta \left[\log \left(\frac{1}{\mu^2} \frac{y_w}{y_h} \frac{1-\bar{n}-\varepsilon-\kappa}{2-\bar{n}-\varepsilon} \right) \right]. \tag{C.11}$$

This expression is similar to equation (12), but differs in two ways: the total household income is y_h instead of $y_w + y_h$, and the wife must bear the search cost κ when divorced.

After the shock, the value of divorce becomes

$$V_w^D(0) = \log(y'_w) + \log(1-\bar{n}-\varepsilon-\kappa).$$

The problem of the single-earner couple if they remain married is similar to that of the dual-earner couple, and the individual value of marriage for the wife is given by equation (10). Since the wife was not employed before the shock, where the job opportunity is given by y_w, and the job opportunity becomes $y'_w < y_w$ after the shock, we have $s_w = 0$. This implies that there is no reduction in household income for this couple due to the shock,

and thus no incentive to increase total resources relative to the pre-shock level, unless y'_h is very high. The individual value of marriage for the wife after the shock remains the same in this case. Using these expressions and PC_w, the probability of divorce after the earthquake is given by

$$F_\theta \left[\log \left(\frac{1}{\mu^2} \frac{y'_w}{y_h} \frac{1-\bar{n}-\varepsilon-\kappa}{2-\bar{n}-\varepsilon} \right) \right]. \tag{C.12}$$

The probability of divorce after the shock (C.12) is lower than that before the shock (C.11), because the wife's job potential deteriorates $y'_w < y_w$. Therefore, the bundling effect is also present for single-earner couples.

Using equations (12-13) and (C.11-C.12), all else equal, the decrease in the probability of divorce is greater for the dual-earner couple than for a single-earner couple if

$$\frac{y'_h}{y_w+y_h} \frac{1-\bar{n}-\varepsilon}{2-\bar{n}-2\varepsilon} \frac{2-\bar{n}-\varepsilon-\kappa}{1-\bar{n}-\varepsilon-\kappa} > 1.$$

It is straightforward to show that this is true if the condition (C.10) is satisfied. In particular, if y'_h is sufficiently high, the bundling effect is stronger for the dual-earner couple than for the single-earner couple.

Q.E.D.

C.3 Proof of Proposition 2

By solving the Pareto problem (9), we know that relative consumption and leisure are given by a proportion characterized only by the decision power,

$$\frac{c_h}{c_w} = \frac{1-\mu}{\mu} = \frac{\ell_h}{\ell_w}.$$

Thus, it is trivial to show that when decision power falls from μ to $\hat{\mu}$ after the shock, both relative consumption $\frac{c_h}{c_w}$ and leisure $\frac{\ell_h}{\ell_w}$ increase, regardless of the level of total household resources.

Using the time constraints (4-5), before the shock, we have

$$\begin{aligned} n_w &= 1-\varepsilon-\ell_w, \\ n_h &= \bar{n}-n_w = \bar{n}-1+\varepsilon+\ell_w. \end{aligned}$$

Similarly, after the shock, solving the Pareto problem of the married couple gives

$$\begin{aligned}\hat{n}_w &= 1-\hat{\ell}_w,\\ \hat{n}_h &= \bar{n}-\hat{n}_w=\bar{n}-1+\hat{\ell}_w,\end{aligned}$$

where hat denotes the allocation after the shock. Combining these equations gives

$$\frac{n_h}{n_w}-\frac{\hat{n}_h}{\hat{n}_w}=\frac{\varepsilon\bar{n}}{n_w\hat{n}_w}>0.$$

Thus the relative childcare time $\frac{n_h}{n_w}$ decreases.

Q.E.D.