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

Online Appendix

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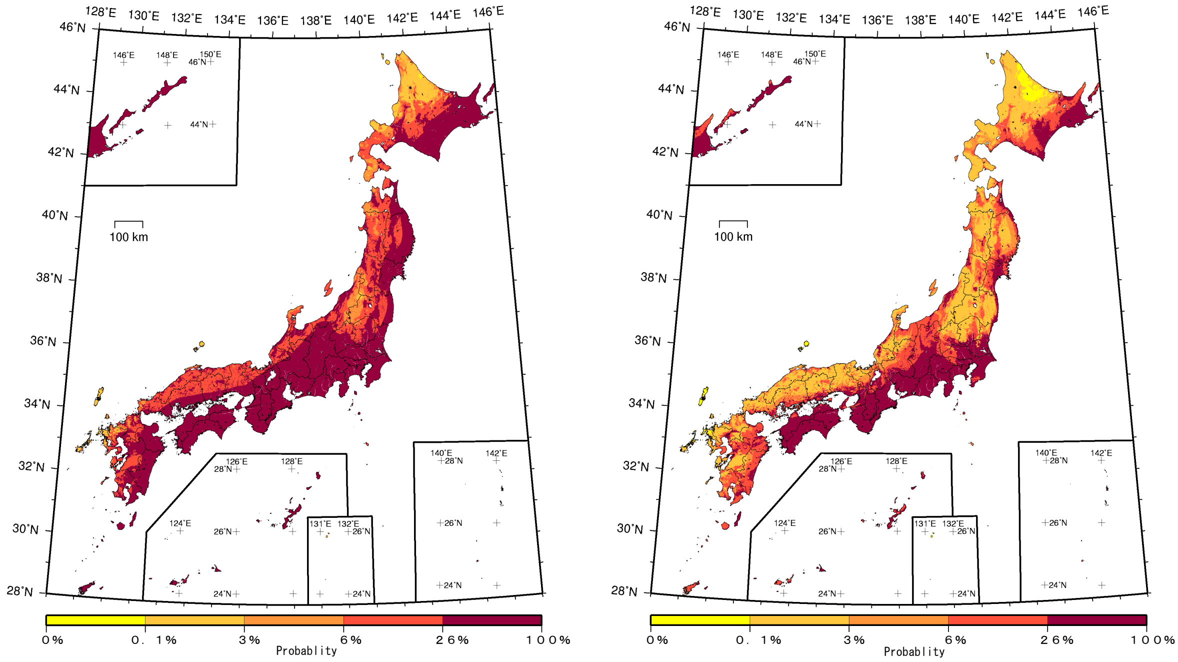


(A) Seismic Intensity ≥ 4.5 (B) Seismic Intensity ≥ 5

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).

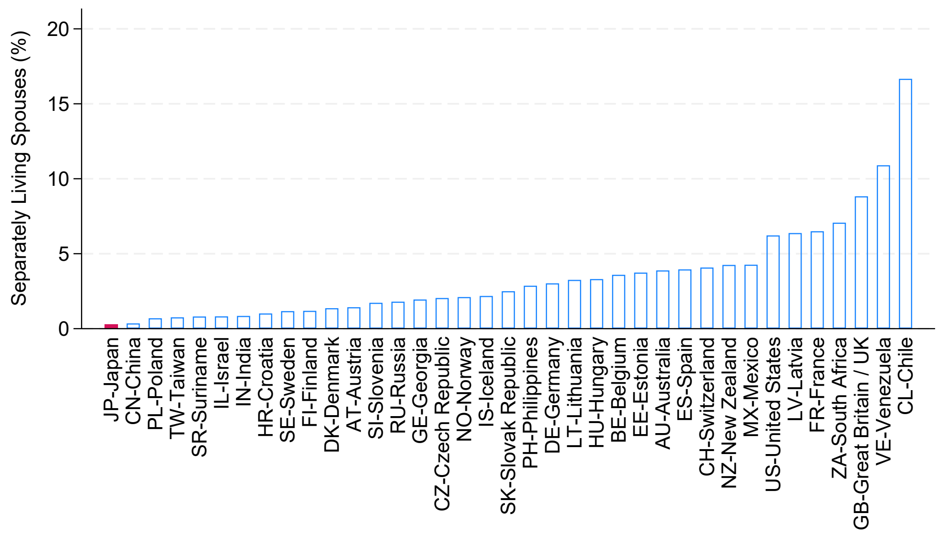


Figure A.2: Percentage of Married Couples Living Separately across Countries. Source: ISSP Research Group (2017)

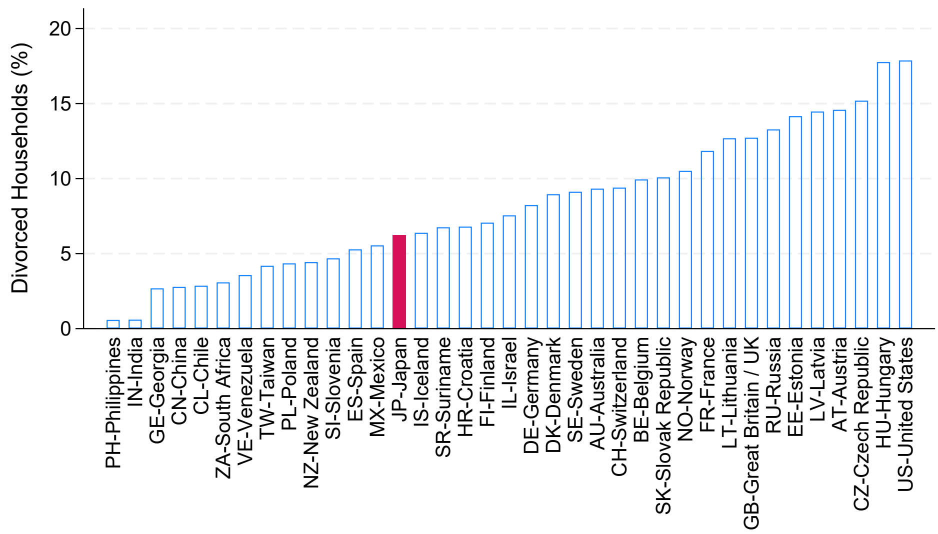
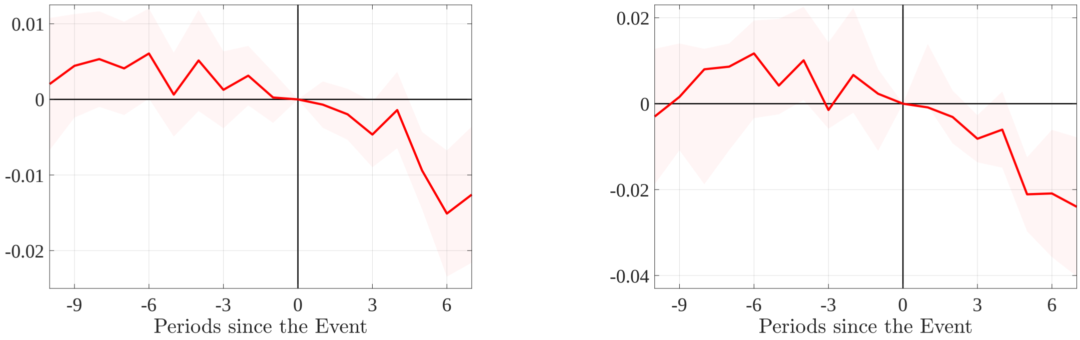


Figure A.3: Percentage of Divorced Households in the Population across Countries. Source: ISSP Research Group (2017)



(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.

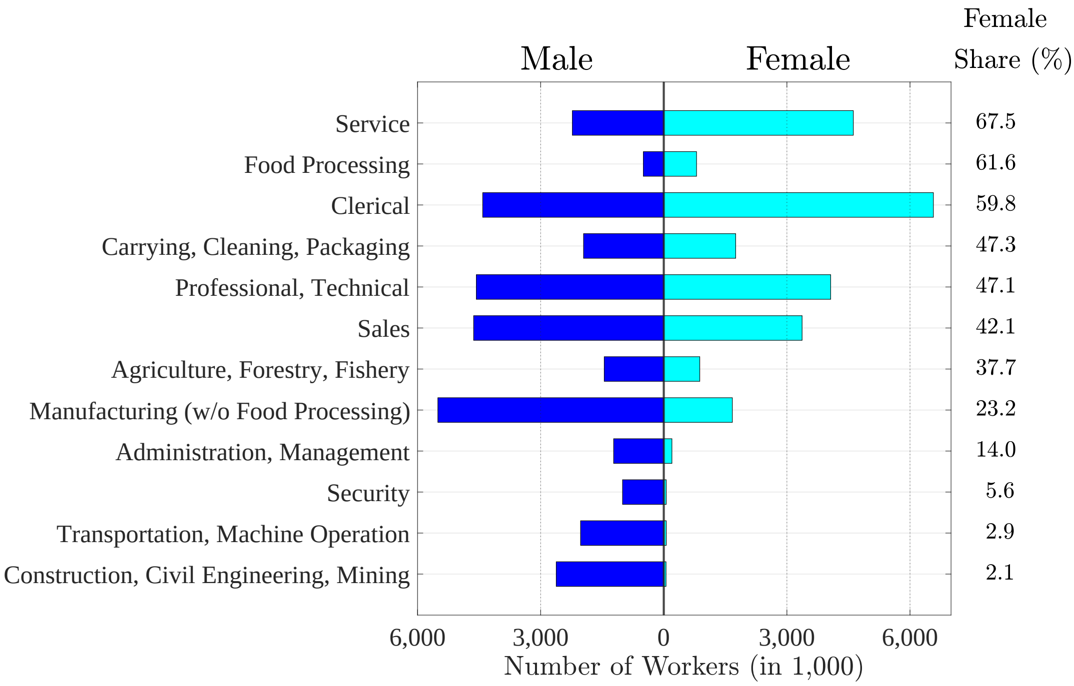
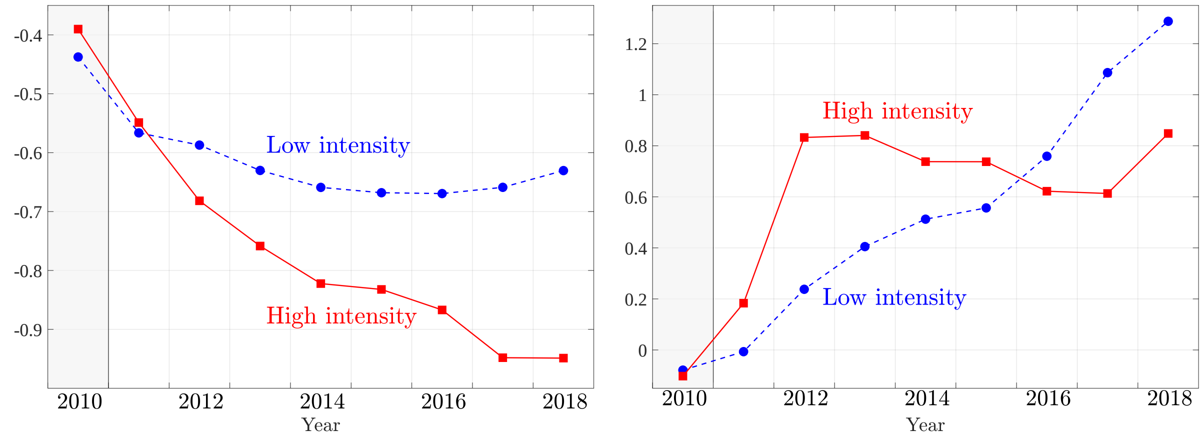


Figure A.5: Number of Employees by Gender in Major Occupations (year 2010). Food processing is separated from general manufacturing for illustration purposes, see text. Occupations are ordered by the proportion of female workers in each occupation, shown on the right axis. Source: Census 2010.



(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 ≥ 4.5		**Treat: seismic intensity ≥ 5**	
	(1) **Logit**	(2) **Dummy**	(3) **Logit**	(4) **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**
Dependent variable	(1) Female earnings	(2) Male earnings	(3) Total income	(4) Female earnings	(5) Male earnings	(6) 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

Dependent variable	**Treat: seismic intensity $\geq$ 4.5**	**Treat: seismic intensity $\geq$ 5**
	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 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.

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.

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.

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

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.

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 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

[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.

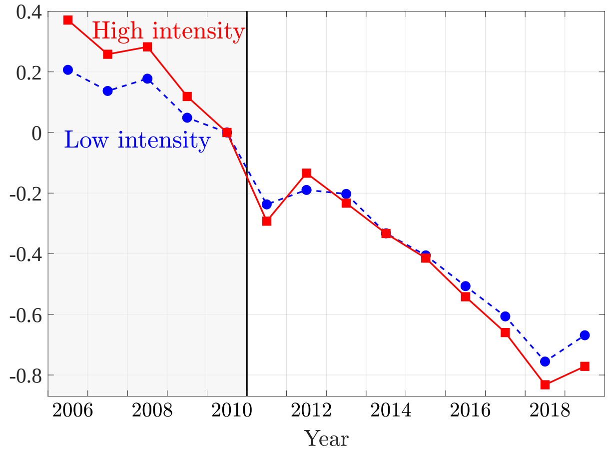


Figure B.1: Marriage Rates at the Prefecture Level. The figure shows the number of new marriages per 1,000 population, relative to 2010. The time of the earthquake is indicated by the vertical line. Source: Vital Statistics from the Ministry of Health, Labour and Welfare, population estimates from the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

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 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

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.

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 $i\in\{w,h\}$,

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

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

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

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

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

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,

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

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

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

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

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

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.,

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

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

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

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:

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

Taking the first-order conditions (FOC) gives

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

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.