Why Don't People Buy Insurance Even After a Catastrophe?

Abstract

Using Japanese data on the purchases of residential earthquake insurance, we test hypotheses concerning how an experience of a major EQ would affect the relationship between EQ insurance take-up and economic and demographic factors, and how the severity of loss experience would marginally change the relationship as well. We find several important implications of catastrophe insurance take-up. First, when the market still has a low penetration, cross-subsidization aiming for level premium rates may not achieve its purpose. Second, some factors becomes important determinants of insurance take-up after an occurrence of a major catastrophe, whether direct or indirect loss experience, explaining the reasons of deterring a take-up surge after a catastrophe. We also show that the post-catastrophe effect of economic and demographic factors depends on the severity of loss experience. Direct loss of a major catastrophe seems overwhelming so that the factors tend to be less relevant to decision making of insurance purchase.

Keywords: catastrophe, earthquake, insurance demand

JEL Classification: D12, D81, D83, G22

1. Introduction

Regardless of public efforts to provide protection against catastrophes at an affordable rate, [1] homeowners have limited interest in mitigating disaster losses (Kunreuther and Pauly, 2004). For instance, the take-up rate of the California Earthquake Insurance Policy is 13.3% in 2017,[2] and the 2016 rate-up rate of the National Flood Insurance Program is roughly 50% even in coastal areas, but it is much lower inland.[3] Although the take-up rate of Japanese residential earthquake insurance policy has increased after experiencing a series of extreme earthquakes, 37% of the primary policyholders have decided not to purchase a rider of earthquake coverage after several extreme earthquakes in 2017.[4]

[1] Due to the difficulty of providing coverage at affordable rates in the private sector, government-backed catastrophe insurance programs have been introduced in disaster prone regions. Examples include residential earthquake insurance programs in Japan and Taiwan, California earthquake insurance, the National Flood Insurance Program in the US, EQC insurance in New Zealand, the Natural Catastrophe Insurance Pool in Turkey, and CCR reinsurance in France. One of the most recent examples is the Terrorism Risk Insurance Act in the US that was instituted after the 9/11 attacks.

[2] California Department of Insurance, Earthquake Premium and Policy Count Data Call – Summary of 2017 Residential Market Totals.

[3] Brookings, "The Hutchins Center Explains: National Flood Insurance Program," October 10, 2017, available at https://www.brookings.edu/blog/up-front/2017/10/10/the-hutchins-center-explains-national-flood-insurance-program/.

[4] Earthquake insurance penetration rate trend reported by the General Insurance Rating Organization of Japan (GIROJ). The data is available at http://www.sonpo.or.jp/insurance/commentary/jishin/reference.html.

Since risk mitigation has gained public interest because of an increasing trend in natural catastrophes and the widespread negative consequences of catastrophic events (Swiss Re, 2016), an important question arise: Why do people decide not to buy catastrophe insurance even after having direct and indirect experience of major catastrophes? One explanation is that catastrophe experience is within their expectation and they do not update their risk beliefs. The findings of temporary reaction to flood experience may be consistent with this explanation (e.g., Gallagher 2014; Aseervatham, Born and Richter, 2013; Atreya, Ferreira, and Michel–Kerjan, 2015). While Kamiya and Yanase (2018) reported substantial nationwide increases studying the impact of extreme earthquakes on earthquake insurance purchase in Japan, there are still a large portion of policyholders have decided not to purchase earthquake coverage.

In this study, we attempt to provide better understanding to the question of why people decide not to buy catastrophe insurance even after experiencing major catastrophes by investigating Japanese households' take-up of earthquake insurance.[5] Specifically, we investigate how cross-sectional heterogeneity of post-earthquake reactions are associated with socio-economic and demographic factors established by the insurance demand literatures and then how those interact with direct and indirect loss experience of catastrophes and affect household purchase of catastrophe insurance.

The catastrophe insurance literature has studied the effect of socio-economic and demographic factors on catastrophe insurance purchase including price (e.g., Browne and Hoyt, 2000; Kousky, 2011; Atreya, Ferreira, and Kriesel, 2013; Atreya, Ferreira, and Michel–Kerjan, 2015), income (e.g., Browne and Hoyt, 2000; Atreya, Ferreira, and Kriesel, 2013; Atreya, Ferreira, and Michel–Kerjan, 2015), age (e.g., Kousky, 2011; Atreya, Ferreira, and Kriesel, 2013; Atreya, Ferreira, and Michel–Kerjan, 2015), gender (e.g., Browne, Knoller, and Richter, 2015), race (e.g., Kousky, 2011; Atreya, Ferreira, and Michel–Kerjan, 2015), education (e.g., Atreya, Ferreira, and Michel–Kerjan, 2015), occupancy (e.g., Kousky, 2011; Atreya, Ferreira, and Michel–Kerjan, 2015), building structure (e.g., Atreya, Ferreira, and Kriesel, 2013), neighborhood (e.g., Atreya, Ferreira, and Kriesel, 2013), mortgage (e.g., Browne and Hoyt, 2000; Kousky, 2011), disaster assistance (e.g., Browne and Hoyt, 2000;). However, the literature has not examined how catastrophe experience would influence the association between those factors and catastrophe insurance purchase. To our knowledge, we are the first to extensively examine the relationship, which provide important implication to catastrophe insurance take-up.

This article considers household take-up of Japanese residential earthquake (EQ) insurance, one of the largest catastrophe insurance programs,[6] and focuses on the effects of the two costliest catastrophes in history, the 1995 Kobe EQ and the 2011 Tohoku EQ (see Figure 1 for the epicenters of these earthquakes).[7] Studying Japanese EQ insurance has several advantages for investigating the influence of EQ experience

[5] Due to limited data availability, we use prefecture-level aggregate data.
[6] In 2015, the total number of contracts in force for the Japanese residential EQ insurance program is 16.8 million (29.5% penetration) with earned premiums of $2.2 billion. In contrast, in 2015, 5 million policies are in force for the US NFIP, with earned premiums of $3.5 billion. This study uses data on EQ insurance contracts obtained from the General Insurance Rating Organization of Japan (GIROJ).
[7] The rankings reported by various sources are not always consistent. For the ranking that supports our statement, see https://www.economist.com/blogs/dailychart/2011/03/natural_disasters.

on socio-economic and demographic determinants of insurance take-up. First, for the two most extreme EQs, people did not self-select into vulnerable areas because the damaged regions have never been recognized as particularly risky relative to other regions. Thus, concerns about the causal relationship are reduced. Second, private insurers do not advertise EQ insurance because it is priced under a no-profit principle and is fully ceded under its reinsurance scheme, which mitigates a concern about the effect of insurers' marketing efforts. Third, the coverage supply constraints discussed by Kunreuther (1996) have never been imposed. The premium rates, determined solely by the General Insurance Rating Organization of Japan (GIROJ), have remained stable due to its rating policy of focusing on equilibrium in the extraordinarily long term, a large government reinsurance-coverage program, and its geographically diversified portfolio. Fourth, households make informed decisions on purchasing EQ insurance coverage. Therefore, the supply-side effect on insurance purchases during a post-quake period is reduced. Details of the Japanese EQ insurance program are provided in Section 2.2.

Using the prefecture-level aggregate data of Japanese residential earthquake insurance take-up, we find several important implications of catastrophe insurance take-up. This study contributes to the literature by adding new findings on the effect of catastrophe experience on the relationship between socio-economic and demographic factors on insurance purchases. Our primary findings are summarized as follows. First, the relationship depends on the stage of insurance market development. For instance, when the market is relatively immature or still has a low penetration, the level of price may not be a determinant of take-up, i.e., cross-subsidization failed to encourage households living in high risk regions to buy a subsidized EQ insurance (i.e., low price elasticity of demand). Second, whether direct or indirect loss experience, an occurrence of a major catastrophe significantly affect determinants of insurance take-up. Especially, risk beliefs formed by catastrophe risk information through media seem to play an important role for households not hit by a catastrophe. This is consistent with the finding by Gallagher (2014). To maintain updated risk beliefs in the post-catastrophe period, insurers and policymakers may prepare a strategic plan to educate consumers and to let them make informed decision on insurance purchase. Relatedly, the level of education plays an important role for insurance take-up only after a major EQ. Contrary to our expectation, an occurrence of a major EQ diminish the role of insurance agents in promoting EQ insurance, suggesting that a post-EQ surge of EQ insurance take-up was mainly driven by the demand. Third, we show that the post-catastrophe effect of social-economic and demographic factors depends on the severity of loss experience. Direct loss of a major catastrophe seems overwhelming so that the factors such as a sales force tend to be less relevant to decision making of insurance purchase.

Overall, our EQ insurance sample shows that direct and indirect loss experience of major EQs provide years of opportunities of promoting catastrophe insurance because individuals update their risk beliefs and insurance take-up is driven by demand side effects. Unfortunately, such opportunities would not arise without severe loss experience. Insurers and policymakers may capitalize on such opportunities by preparing their marketing strategies and implement the plan in a proper timing. We believe that our findings have a broad implication in that such strategic approach of promoting catastrophe insurance may be useful for the market struggling to increase take-up rate such as California earthquake insurance offered by CEA and The National Flood Insurance Program (NFIP) in US. Especially, the take-up rate of NFIP policy surged after major floods, though the increase is only temporary, suggesting that households are certainly reactive to a direct and indirect loss experience, i.e., their risk beliefs are updated upon an arrival of new flood information. To maintain the updated belief, flood risk information should be timely distributed through media to help households to make informed decisions on flood risk mitigation.

The remainder of this paper is organized as follows. A brief description of extreme earthquakes in Japan and the Japanese residential EQ insurance program is provided in Section 2. The related literature is reviewed and hypotheses are discussed in Section 3. Section 4 describes our methodology and data. In Section 5, we discuss the estimation results. Section 6 summarize the policy implications and Section 7 concludes.

2. Earthquakes and Earthquake Insurance in Japan

2.1. Extreme Earthquakes and EQ Insurance Penetration

Earthquakes are the deadliest natural disasters in Japan. In the last one hundred years, EQs in Japan accounted for 80% of the deaths caused by all natural disasters and have killed approximately 194 thousand people (CRED 2016).[8] Therefore, the EQ risk is well recognized by Japanese. To illustrate household EQ insurance purchase, Figure 2 shows the median growth of residential EQ insurance take-up rates in Japan,[9] indicating a record high in 1995 after the Kobe EQ that occurred on January 17, 1995 (magnitude 7.3; approximately 650 thousand houses were damaged; more than 6,434 people were killed).[10] Thus, the 1995 Kobe EQ caused a surge in demand for protection for the entire country, although significant damage was limited mostly to the Hyogo Prefecture.[11] Furthermore, in contrast to existing studies arguing that catastrophes have a temporary effect on demand for protection due to individuals' irrational behavior (e.g., Gallagher 2014; Aseervatham, Born and Richter, 2013; Atreya, Ferreira, and Michel–Kerjan, 2015), the consistent positive growth of insurance take-up rates indicates that households did not have a tendency to cancel EQ coverage during the post-Kobe period.[12]

We also observe additional growth after the 2011 Tohoku EQ (magnitude 9.0; approximately 1.2 million houses were damaged; 18,493 people were killed, and 2,683 people were missing), particularly in prefectures that suffered, such as the Fukushima prefecture, which experienced a 51% increase of insurance take-up rates after the EQ experience.

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[8] D. Guha-Sapir, R. Below, Ph. Hoyois - EM-DAT: The CRED/OFDA International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium.

[9] The number of policies is separated by fiscal year (April-March). The EQ insurance data are obtained from the General Insurance Rating Organization of Japan (http://www.giroj.or.jp/).

[10] Data on earthquakes are obtained from the Japanese Meteorological Agency website: http://www.jma.go.jp/jma/indexe.htm

[11] A total of 99.5% (6,402 out of 6,434) of EQ-related deaths and 99.1% (104,004 out of 104,906) of the destruction of residential buildings is reported within the prefecture. This information is available at http://web.pref.hyogo.jp/pa20/pa20_000000015.html (in Japanese).

[12] A contract for EQ insurance does not include an automatic renewal clause. Therefore, this insurance must be renewed annually unless it is a multi-year contract.

2.2. Japanese Residential Earthquake Insurance Program

In Japan, EQ insurance coverage for residential buildings and movables for living is subject to the Act Concerning Earthquake Insurance.[13] Pursuant to the related acts, the Japanese residential EQ insurance system was established with the "Japanese Earthquake Reinsurance" scheme in 1966; since then, the scheme has been revised several times after major EQs.[14] To ensure stable management of the system, the Act determines the specification of coverage, payment standards, underwriting limits, reinsurance, and accounting treatments (see GIROJ, 2014, for details). The most important component of this system is that the EQ insurance system is backed by government reinsurance to secure payments up to a total of 11.3 trillion yen (approximately 113 billion USD as of July 2016) per earthquake, which should be adequate to pay claims even for an extremely large EQ equivalent to the 1923 Great Kanto EQ.[15]

More specifically, EQ insurance coverage underwritten by primary (private) insurers under this system is 100% ceded to the Japan Earthquake Reinsurance Co. Ltd. (JER), which was established to manage only this insurance. A portion of the reinsured coverage is retained by the JER. However, the remaining portion is transferred to private insurers and the government so that the first layer of coverage, up to 88.4 billion yen, is 100% paid solely by JER. The next layer, up to 126.8 billion yen, is equally shared between private insurers and the government (19.2 billion yen each). The next layer, up to 224.4 billion yen, is equally shared between the JER and the government. Since 2016, 99.8% of the top layer, up to 11.3 trillion yen, has been paid by the government. Thus, in cases in which insurance claims per earthquake exceed a certain layer, excess liabilities are shared by the relevant organizations. As Figure 3 shows, the JER plays a role in standardizing the risks insurers underwrite, and then re-distributes them to the relevant organizations – the JER, private insurers, and the government (The Special Account for Earthquake Reinsurance).[16] Although primary private insurers receive reinsurance premiums as compensation for taking on insurance liabilities in the EQ insurance system, the share is quite small. For the current limit of 11.3 trillion yen liability, the limit of liability for primary insurers is only 22.3 billion yen (0.2%), whereas JER and the government are responsible for up to 150.9 billion yen (1.3%) and 11.1 trillion yen (98.5%), respectively. The net reinsurance premium paid from the JER to private insurers in 2015, for instance, was approximately 140 million (0.5%) in total.[17]

[13] EQ insurance coverage for commercial properties is not subject to this law.

[14] Revisions of the system were made in 1980, 1991, 1996, 2001, 2005, 2007, 2010, and 2014. The revisions include changes in coverage, limits, premium rates, discount rates, and loss assessment standards.

[15] The Great Kanto Earthquake hit the Tokyo area in 1923 and resulted in the largest amount of fire damage due to an earthquake in Japan; 447 thousand buildings were completely burned down, and 142,000 people were killed. For a comparison, the earthquake insurance paid out 1.27 trillion yen (approximately 23% of the reinsurance program limit) for the 2011 Tohoku earthquake.

[16] The Special Account for Earthquake Reinsurance was established to clarify the accounting for the EQ insurance system whereby the government reinsures massive earthquake damage in excess of a certain amount. If claims exceed the total limit, then the claims are pro-rated among all claimants.

[17] Authors' calculation. According to JER's 2015 financial report, the total net premium ceded from private insurers to the JER was 257.2 billion yen, of which 121.9 billion yen was retained in the JER and 115.3 billion yen was further ceded to the government reinsurance program. From the information, it is estimated that 140 million yen was ceded to private insurers.

The EQ insurance covers losses due to fire, destruction, burial or flooding either directly or indirectly caused by an earthquake, volcanic eruption or tsunami. Insurance premium rates are required to be as low as possible but maintain equilibrium between income and expenses. Reinsurance premium rates are required to be reasonable to ensure an adequate reinsurance premium income to pay reinsurance claims in the extraordinarily long term (Article 5, The Act Concerning Earthquake Insurance). The premium is based on a no-profit and no-loss principle; it includes a pure premium rate and expense loading, which is calculated by GIROJ.[18] To estimate potential EQ insurance claims without sufficient experience data, potential damages are estimated with simulations based on the Probabilistic Seismic Hazard Map published by the government's Headquarters for Earthquake Research Promotion.[19] By using the simulated damage data, pure premium rates are determined by estimating the insurance claims to be paid per year. The standard premium rates are classified using two risk criteria: the geographic region (4 zones)[20] and the building structure (whether it is a fireproof building). Thus, the risk is not finely classified, and cross-subsidization can occur between risks (Naoi, Seko, and Sumita, 2010). However, the accuracy of the pure premium rate has never been verified, and the method of using long-term forecasts to generate the Probabilistic Seismic Hazard Map is under debate in the fields of seismology and geophysics. For instance, Geller (2011) argues that the method is flawed and that earthquakes cannot be reliably predicted. Thus, it is not possible to determine whether the pure premium rates accurately reflect the riskiness of earthquakes due to the infrequency of disastrous EQs. However, the hazard map is well publicized by government agencies, and it is reasonable to assume that homeowner beliefs about the likelihood of a large earthquake are based on the hazard map.

Concerning the distribution of EQ insurance, insurance companies offer coverage not as a standalone policy but as an optional rider for fire insurance policies. Although primary insurers do not actively advertise EQ insurance coverage, insurers must inform their fire insurance policy purchasers of the availability of EQ coverage, and the policy purchasers must acknowledge their decision not to purchase the rider by signing on a policy application. The practice was adopted before our sample period to support policyholders' informed decisions, and has it not been changed. Thus, policyholders are aware of the availability of EQ coverage and decide whether to purchase the coverage. The amount insured by the EQ insurance coverage must be fixed within 30–50% of the principal contract. To simplify loss adjustment and reduce time to claim payment, the degree of loss is categorized into only three types according to assessment guidelines: total loss, half loss or partial loss. Payment of insurance claims is also simplified: 100% of the amount insured for a total loss, 50% for a half loss, and 5% for a partial loss.

To address concerns that the supply side restricts the purchase of the EQ insurance, we highlight the following institutional characteristic of the EQ insurance system. First, coverage supply has never been

[18] The expense loading rates include operation expenses, loss adjustment costs, and agency commission fees. These rates do not include profits for insurers.
[19] The Probabilistic Seismic Hazard Map has been used since 2007. Before 2007, the Chronological Scientific Tables that include super long-term hypocenter nationwide data were used.
[20] There were only 3 classes before April 1, 1991 and after July 1, 2014

restricted on the market because the aforementioned government reinsurance program are more than sufficient for take-up (26% in 2014). Reinsurance claims paid in the mega EQs were 78 billion yen (4.3% of the limit of the reinsurance program) for the 1995 Kobe EQ and 1.27 trillion yen (23.1% of the reinsurance limit) for the 2011 Tohoku EQ.[21] The limit on the total amount of insurance claims further expanded to 11.3 trillion yen in October 2016. Concerning sufficient capacity, no past major earthquakes have ever caused a spike in the base rates due to the rating policy of focusing on equilibrium in the extraordinarily long term (GIROJ, 2014).

3. Literature and Hypotheses

The catastrophe insurance literature has studied the effect of socio-demographic factors on catastrophe insurance purchase including price (e.g., Browne and Hoyt, 2000; Kousky, 2011; Athavale and Avila, 2011; Atreya, Ferreira, and Kriesel, 2013; Atreya, Ferreira, and Michel–Kerjan, 2015), income (e.g., Browne and Hoyt, 2000; Athavale and Avila, 2011; Botzen and van den Bergh, 2012; Atreya, Ferreira, and Kriesel, 2013; Atreya, Ferreira, and Michel–Kerjan, 2015), age (e.g., Kousky, 2011; Botzen and van den Bergh, 2012; Atreya, Ferreira, and Kriesel, 2013; Atreya, Ferreira, and Michel–Kerjan, 2015), gender (e.g., Botzen and van den Bergh, 2012; Browne, Knoller, and Richter, 2015), race (e.g., Kousky, 2011; Atreya, Ferreira, and Michel–Kerjan, 2015), education (e.g., Botzen and van den Bergh, 2012; Atreya, Ferreira, and Michel–Kerjan, 2015). Some studies also consider the factors related to insured properties including building structure (e.g., Atreya, Ferreira, and Kriesel, 2013), occupancy (e.g., Kousky, 2011; Atreya, Ferreira, and Michel–Kerjan, 2015), neighborhood (e.g., Atreya, Ferreira, and Kriesel, 2013), mortgage (e.g., Browne and Hoyt, 2000; Kousky, 2011), disaster assistance (e.g., Browne and Hoyt, 2000). However, the prior literature has little attention to how the association of these factors with insurance take-up are affected by loss experience. One notable exception is that Gallapher (2014) examine the effect of media coverage on individuals' learning of flood risk after major floods.

The related psychology literature has also extensively studied the relationship between catastrophe risk perception/mitigation and some demographic factors (see, Lindell and Perry, 2000, and Bubeck, Botzen, Aerts, 2012, for the review of factors that would be associated with mitigation behavior for earthquake and flood, respectively). The factors includes age, gender, income, education, marital status, household size, and ownership. Thus, factors that have been studied in economic and psychological literatures primarily coincide.

Empirical studies on catastrophe insurance have indicated a demand surge after loss experience (e.g., Browne and Hoyt, 2000; Michel-Kerjan and Kousky, 2010; Atreya, Ferreira, and Michel–Kerjan, 2015). Although the effect of a direct loss on insurance demand appears robust, studies also report that the post-loss insurance demand surge is short-lived (e.g., Michel-Kerjan et al., 2012; Aseervatham, Born and Richer,

[21] The limit of the reinsurance program was 1.8 trillion yen immediately before the 1995 Kobe EQ and was increased to 5.5 trillion yen before the 2011 Tohoku EQ. After several further revisions, the limit was expanded to 11.3 trillion yen in October 2016.

2013; Gallagher, 2014). In contrast, Kamiya and Yanase (2018) find that insurance take-up increase is persistent temporally and spatially, meaning that indirect loss experience also substantially increases insurance demand. However, these studies attribute the change in demand to behavioral reasons such as availability heuristics and representativeness, controlling for the average effects of socio-economic and demographic characteristics during the sample period. In other words, their empirical models treat socio-economic and demographic factors as time constant over a sample period and do not consider the change of their impact on insurance take-up during a post-catastrophe period.

Specifically, we have two primary arguments. First, the effect of socio-economic and demographic factors on insurance take-up would be affected after a catastrophe experience. For instance, provided that a catastrophe is a low probability, severe loss event, individuals' information processing that determines their risk beliefs and risk mitigation behaviors would be affected by emotional reactions to risky situations (Loewenstein, 2001). For instance, Fischhoff et al. (2003) show that risk beliefs and behaviors after the September 11th attacks are heterogeneous between demographic groups (e.g., gender and age groups). This leads the following hypothesis.

HYPOTHESIS 1 (Post-loss effect): When individuals make decisions concerning the purchase of insurance, the influence of socio-economic and demographic factors is affected by catastrophe loss experience.

The prediction for each factor is discussed in Section 3.1. To examine the first hypothesis, we adopt a difference-in-differences approach by interacting the socio-economic and demographic terms with post-quake period year dummies.

Our second argument is that the post-catastrophe effect of socio-demographic factors depends on the severity of loss experience: a direct (loss experience to its own) or indirect (loss experience to others) loss experience. For instance, Fischhoff et al. (2003) report that risk perception after the September 11th attacks not only varies by demographic groups but also related to the distance from the World Trade Center, considered as a proxy of emotional distance. Therefore, we argue that the severity of experience would affect the influence of socio-economic and demographic factors on insurance take-up after a catastrophe.

HYPOTHESIS 2 (Direct loss experience effect): When individuals make decisions concerning the purchase of insurance, the influence of some socio-economic and demographic factors on insurance take-up affected by the severity of catastrophe loss experience.

Again, the prediction for each factor is discussed in Section 3.1. The second hypothesis is examined by introducing interaction terms between the socio-economic and demographic terms and EQ experience severity measures. We first examine two direct loss measures: the direct-loss experience indicator variable

(*Damage*), which equals one for prefectures that experienced damage to residential buildings and zero otherwise; the percentage of damaged residential buildings in a prefecture per household (*Damage Rate*).[22]

Strong ground movement may create fear which may contribute to shaping risk perception (Loewenstein et al, 2001). For instance, fear triggered more pessimistic risk perception (Lerner and Keltner, 2000, 2001) and plans for precautionary measures after disasters (e.g., Rüstemli and Karanci, 1999; Lerner et al., 2003). Studying California EQ insurance purchases, Palm (1995) finds that risk perception is a more important determinant than is past experience in earthquake insurance purchases. Considering the effect of extreme EQs in this study, we expect that emotion that should be affected by vivid and dramatic news would also substantially affect EQ insurance purchases by those who have not experienced loss (Johnson et al., 1993), although the extent of the emotional effect is not clear for the deadly disasters.

To examine the effect of ground movement, we prepare three indicator variables as proxies of the magnitude of loss experience, using the Japan Meteorological Agency seismic intensity scale, which ranges from 0 (smallest) to 7 (largest). The first intensity measure is an indicator variable for intensity level k or above (*Intensity Level k*), where $k = 4, 5, 6$. We chose the intensity level thresholds based on the finding that seismic intensity level was related to household reactions only when the intensity level could cause a direct loss experience (Kamiya and Yanase, 2018), though the extent of property damages directly caused by ground shaking is limited or even none for these intensity levels unless a tsunami causes damages.

3.1. Socioeconomic and Demographic Factors

The catastrophe related literature provides fruitful implications to our prediction for each socioeconomic and demographic factors. First, Fischfoff et al. (2003) study the relationship between risk judgement and age, gender, and distance from WTC (as a proxy for psychological distance) after September 11th attack. They find that terror-related risk perception is negatively related to the distance from WTC, age, and male. They also find, in terror risk perception, a strong age-distance interaction that middle-aged individual groups (38–47 age groups) show less terror risk perception when outside the WTC area. Similarly, they showed a significant gender-distance interaction that males outside the WTC area saw less terror risk than did men inside, whereas females are not sensitive to the distance. Inside the WTC area, men and women had similar mean terror risks judgments. The results implies that the effects of age and gender on insurance take-up, if they exist, would be affected by the extent of catastrophe loss experience, though the detailed predictions of the interactions is not clear. To examine the effect of age and gender in our prefecture-level aggregate data, we construct the average age (*Age*) and the ratio of female population to male population (*Gender*).

Previous insurance consumption studies unanimously agree that disposable income is the most important factor to capture the relationship between economic development and insurance consumption (Outreville, 2013), although the relationship does not necessarily hold for purchase of catastrophe insurance For instance, Palm and Hodgson (1992) show that income is not a determinant of purchase of California

[22] Table 1 provides the definitions of the variables used in our analyses.

earthquake insurance. Using the Japanese earthquake insurance data, Kamiya and Yanase (2018) also find that the level of average income is not a determinant of the purchase of earthquake insurance. Regardless, the purchase of earthquake insurance may increase because households are the value of insurable assets and potential liability increases as the economy develops and/or because household with limited fund may not choose to buy insurance, which is state-contingent saving (Rampini and Viswanathan, 2017). Therefore, we consider household disposable income (*Income*) in our analyses. We predict that fear of income volatility due to future earthquake increases after an earthquake and hence marginally increase insurance take-up (H1). We further predict that direct loss experience marginally increases insurance purchase due to strong fear to be a victim of a future earthquake (H2).

Household demand for insurance coverage is also affected by the portfolio of assets. The literature suggests that savings has a substitution effect on insurance consumption (see, Dionne and Eechhoudt, 1984; Rampini and Viswanathan, 2017). Therefore, we define the variable *Savings* as percent of income and predict that a negative relationship exists between savings and EQ insurance take-up. Kamiya and Yanase (2018) find that the level of savings is not a determinant of the purchase of earthquake insurance. However, the substation effect may become stronger after a catastrophe and even more for those who experienced direct loss due to increased risk perception to a future catastrophe.

The price of the insurance is certainly one of the determinants of insurance take-up and may be expected to be negatively related to non-life insurance demand (e.g., Browne, Chung, and Frees, 2000). As described in Section 2.2., the rating scheme is determined by no-loss no-profit principle and set solely by GIROJ. However, the premium rates are not finely classified, and cross-subsidization occur between risks (Naoi, Seko, and Sumita, 2010). During most of our sample period, prefectures were classified into only 4 classes and the premium rate difference between the 4 classes was a factor of 3-4. A potential cross-subsidization between prefectures gives households living in high risk regions a discount and those living in low risk regions an additional burden. Therefore, we consider the premium rates set by GIROJ as the prices of EQ insurance coverage.

Using the same *Price* measure as the average EQ insurance premium rate per 1000 yen insured, Kamiya and Yanase (2018) find the negative relationship for Japanese earthquake insurance and show that a 1% increase in the price was associated with a 0.6% decline in insurance take-up. We predict that the negative relationship between price and insurance take-up becomes more evident after an extreme earthquake because more price-elastic households (e.g., less risk averse and/or weak risk perception to a future earthquake) start purchasing insurance after the major earthquake experience. Although it is reported that an overall take-up increases after an earthquake, the price elasticity to insurance take-up is expected to be stronger after an earthquake experience. Regardless, how direct loss experience affects the negative relationship is not clear because a strong emotional reaction may dominate the price sensitivity.

Theoretical studies show that the degree of risk aversion is expected to have a positive effect on insurance consumption (e.g., Pratt, 1964). In empirical studies of insurance demand, the level of education in a country is often used as a proxy for risk aversion (e.g., Truett and Truett, 1990; Browne et al., 2000; Ward and Zurbruegg, 2000). The general hypothesis is that a higher level of education may lead to a greater degree of risk aversion and better knowledge of insurance products. On the contrary to the hypothesis, using the variable *Education* as the ratio of college education school enrollment as a proxy for consumers' risk aversion, our prior study finds a negative association between the level of education and insurance take-up. We predict that the effect difference by the level of education would emerge after a catastrophe experience because less educated individuals are expected to overreact and purchase insurance coverage more (i.e., more emotional reaction) than highly educated individuals do. Similarly, we hypothesize that the negative relationship between the level of education and insurance take-up present for those who suffer a direct loss experience, which would lead a stronger emotional reaction.

We examine the effect of the sales force by considering the number of insurance agents per household (*Agent*) because insurance agents are expected to play a significant role in promoting EQ insurance, especially after large earthquakes. It is expected that disasters may make them easier to sell policies due to increased risk awareness (belief update) of households. Therefore, we hypothesize that sales force is positively related to take-up after a major earthquake and the relationship is expected to be reinforced by a direct loss experience.

Lastly, we consider the effect of exposure to disaster information reported by news sources defined by the number of newspapers purchased per household (*Newspapers*). This measure is expected to be positively related to take-up after an earthquake and the relationship is expected to be stronger for those who did not experience loss. Since their risk belief is updated by information obtained from news sources, the exposure to news media would positively affect their risk perception and risk mitigation behaviors.

By studying sub-national level observations, we relax concerns on the legal environment, religion, and other social factors. Although heterogeneities between prefectures may exist, they are expected to be controlled by subject fixed effects.

In addition, we consider two factors that control for heterogeneity between prefectures: fire insurance policies, and home insurance policies offered by the Japan Agricultural Cooperatives (JA). First, the take-up rate of fire insurance offered by private insurers must be controlled for because, as described earlier, residential EQ insurance coverage is offered as an optional rider to fire insurance policies. To control for the constraint of the main policy, the variable *Fire Insurance* is calculated as the number of fire insurance policies per household. This variable is expected to be positively associated with EQ insurance take-up.

The second factor is the market penetration of home insurance policies offered by Japan Agricultural Cooperatives (JA). The JA home insurance policies are priced lower than private insurance policies and cover EQ risk in the principal contract. Although the JA insurance products are sold mainly to farmers, non-farmers can purchase JA insurance products by becoming a member of JA. Due to the competitive products of the JA, the JA home insurance policy is dominant in rural areas and could reduce the numbers of private insurance policies. Therefore, we control for these policies by introducing *JA Insurance,* which is calculated as the number of JA home insurance policies per household.

4. Methodology

4.1. Empirical Models

To evaluate the take-up of EQ insurance, we consider the following function of the determinants discussed earlier, which can be stated as

$$P = f(s, x)$$

where P is household take-up of a residential earthquake insurance policy, s is a vector of EQ related measures, and x is a vector of socio-economic and demographic including the price of the EQ insurance and exposure to a loss that can be covered by a fire insurance policy. For the dependent variable, we calculate a measure for EQ insurance take-up: the number of properties insured per household (*EQ Insurance*). Our primary objective is to understand how the insurance take-up rate P is affected by the occurrence of extreme earthquakes, which is denoted by s, after controlling for other factors.

The relationship is estimated by the sensitivity of each factor to EQ insurance take-up:

$$P = p^{\beta_1} \times q^{\beta_2} \times \prod_{k=1}^{K} s_k^{\gamma_k} \times \prod_{l=1}^{L} x_l^{\delta_l} \quad (1)$$

To test the hypothesis 1, we employ the following specification:

$$\log P_{it} = \alpha + \alpha_i + \sum_t \alpha_t + \sum_{kt} \beta_{kt} s_{kit} + \sum_l \delta_l \log x_{lit} + \sum_t \eta_t (post_t \times \log x_{lit}) + \varepsilon_{it} \quad (2)$$

where α_i and α_t are prefecture and year fixed-effects and coefficients β, δ, and η reflect the sensitivity between the take-up and each factor. The *post* variable is an indicator with 1 for post-earthquake period; 0 otherwise. Subscripts k and l represent the number of variables of interest and other explanatory variables, respectively. The post-quake measures represented by the parameter s take the form of interaction terms between post-quake year dummies and EQ related terms.

To test the hypothesis 2, which consider interaction between the severity of loss experience and socio-economic and demographic factors, we employ the following specification:

$$\log P_{it} = \alpha + \alpha_i + \sum_t \alpha_t + \sum_{kt} \beta_{kt} s_{kit} + \sum_l \delta_l \log x_{lit} + \sum_{tk} \eta_t (s_{kit} \times \log x_{lit}) + \varepsilon_{it} \quad (3)$$

where the interaction term is expected to capture the heterogeneity of the sensitivity of social-demographic factors to insurance take-up.

4.2. Data

Japanese earthquake insurance data obtained from GIROJ are prefecture-level (47 prefectures) and aggregate the number of properties insured. All explanatory variables are also collected at the prefecture level from various data sources. The definitions and summary statistics of the variables are presented in Tables 1 and 2. The development of the EQ insurance market can be observed by comparing EQ insurance variables in Table 2. The mean EQ insurance take-up rate was 7.6% during the Kobe EQ period (FY1990-

1998) and increased to 21.7% during the Tohoku EQ period (FY2006-2014), indicating a substantial increase in EQ insurance penetration. The averages of income, savings, JA insurance, insurance agents, and newspapers decreases in the Tohoku EQ sample period.

The EQ measures are separately reported for both the Kobe and Tohoku EQs. The damage variables indicate that damages were concentrated in the Kobe EQ (8.5% of prefectures) and spatially distributed in the Tohoku EQ (40.4% of prefectures), which is supported by differences in the average number of damaged households.

To evaluate the change in household insurance take-up when an extreme EQ occurs, we first identified the events to be investigated. In Japan, ground movements occur quite frequently. Table 3 shows that seismic intensity level-1 EQs are recorded 1871.9 times per year (5.13 times per day) somewhere in Japan during the sample period. Even level-6 EQs occurred more than once a year on average. However, most EQs do not cause any damage or have very limited impacts because strong movement that could cause property damage tends to occur in a small region, and modern buildings have adopted earthquake-resistant structures in Japan.

Only three earthquakes are recorded as intensity level-7 during the sample period: the 1995 Kobe earthquake (magnitude 6.9), the Chuetsu earthquake in 2004 (magnitude 6.6), and the 2011 Tohoku earthquake (magnitude 9.0). Although the types of damage differ, these three earthquakes killed many people and caused property damage. However, among these three earthquakes, the 2004 Chuetsu EQ is not comparable to the Kobe EQ (city inland earthquake) or the Tohoku EQ (known for large tsunami waves) regarding the amount of property damage and the number of dead and injured.[23] Therefore, we mainly focus on the effect of experience for the Kobe and Tohoku EQs, the two costliest disasters in history, and evaluate the impact of these EQs separately using different sub-samples: FY1990-1998 for the 1995 Kobe EQ and FY2006-2014 for the 2011 Tohoku EQ.

We investigate the impact of these two EQs separately for two reasons. First, the EQ insurance market developed substantially during the overall sample period. Figure 4 plots the take-up rate by each prefecture and shows the increasing trend of the market. Another reason is that these two major EQs are quite different in terms of the major causes of building damage: destruction by shaking followed by fire for the Kobe EQ and a tsunami for the Tohoku EQ. We believe that the shock of the extreme EQs on insurance take-up could also be significantly different; therefore, we study them separately.

5. Estimation Results

To estimate equations (2) and (3), we investigated several different regression specifications and conducted the Lagrange multiplier test and the Hausman test to choose a specification. The results of these

[23] Regardless of the intensity of the 2004 Chuetsu EQ, it caused much less damage than the Kobe EQ primarily because the Chuetsu EQ struck a region with low population density. Only 68 people were killed, which is approximately 1% of the fatalities cause by the Kobe EQ.

tests suggest using a fixed-effect model due to the presence of within-subject correlation. Therefore, we report the parameter estimates using OLS regressions with both subject and time fixed effects, both of which are shown statistically significant by *F*-tests. Thus, we evaluate *within-prefecture variation* of EQ insurance take-up. Concerns about potential omitted variable bias are reduced because the subject fixed effects absorb the time-constant omitted variables. We report statistical significance based on prefecture cluster robust standard errors.

We exclude *age* and *gender* variables from the regression models due to their small variations over time and their collinearities with year dummy variables.

5.1. Effect of Socio-Demographic Factors on EQ Insurance Take-Up after Kobe EQ

We first investigate how the 1995 Kobe EQ affected EQ insurance take-up and then look into its effect on economic and demographic factors. Note that there have been no other direct losses in the region suffered by the Kobe EQ during the sample period. [24] We also note that the occurrence of the earthquake falls in the last quarter of fiscal year 1994 because the fiscal year starts on April 1st and ends on March 31st. To investigate the effects of the extreme earthquake, we restrict our sample from FY1990 to FY1998, including 4 years before and after the year of the EQ.

The estimation results for the effect of a direct experience with the Kobe EQ are summarized in Table 4.[25] The dependent variable is the log-transformed number of EQ insurance policies per household. Model 1 includes the economics and demographic variables and year dummy variables except one for FY1993 (EQ Year 1), which is used as the reference year.[26] Models 2 and 3 include the post-quake interaction terms. The economic and demographic factors interact with the post-quake period dummy (i.e., one in 1994-98 and zero otherwise) in Model 2 and with year indicator variables for the post-quake years in Model 3 to investigate the post-quake trend, which is summarized in Figure 5.

Model 1 indicates that the number of primary policy and the price are significant determinants of EQ insurance take-up on average during the sample period. It is reasonable that the size of potential market of EQ insurance is positively related to the size of EQ insurance take-up – a 1% increase of the size of fire insurance policies is related to a 1.2% increase in EQ insurance take-up. Negative price elasticity is also reasonable – a 1% increase in EQ insurance price is related to a 0.6% decrease of EQ insurance take-up. No other economic and demographic variables are significantly related to EQ insurance take-up. However, the post-EQ year dummy variables indicate a substantial increase of the take-up after the Kobe EQ. For instance, 4 years after the EQ year, the country average EQ insurance take-up marginally increased by 91%. Thus, a strong positive effect of the Kobe EQ experience is confirmed.

[24] The history of EQs that have affected the Hyogo Prefecture is available in Japanese at http://www.jishin.go.jp/main/yosokuchizu/kinki/p28_hyogo.htm.
[25] We exclude prefectures that directly suffered from other EQs during the sample period (e.g., 3 prefectures in Models 1–3 and 4 prefectures in Models 4–6), although the estimation results are mostly unaffected by the treatment of the sample.
[26] This setting of time fixed effects is consistent with Gallagher (2014).

Model 2 including the post-EQ interaction terms show that there are changes in the impact of the economic and demographic factors after the Kobe EQ. First, the price effect is negative and significant only after the EQ. During the post-EQ period, a 1% increase of the price reduces take-up by 0.48%. Thus, the significant price elasticity of demand emerges after the EQ, implying that before the EQ, insurance purchasers are not price sensitive but after the EQ price-sensitive consumers start purchasing the coverage. Education has a positive effect during the post-EQ period in that a 1 percentage point increase in education increase take-up by 1.7%. We also find that a positive effect of newspapers and a negative effect of insurance agents during the post-EQ period, which largely offset the coefficients of their standalone variables. The newspaper term has large positive effects (1.07), implying that information from news sources played an important role for household decision making on EQ insurance purchase after the EQ. On the contrary, the post-EQ agent terms turn to be negative and larger in the magnitude, which mostly offsets with the estimated coefficient for the standalone agent variable. The total of these coefficient implies that insurance agents help promote EQ insurance before the Kobe EQ. However, the Kobe EQ diminished the role of insurance agents and after 4 years the marginal effect mostly disappear, i.e., insurance agents no longer be a determinant of EQ insurance take-up. This may imply that individuals might learn and become aware of EQ risk, and rely more on their own assessment of EQ risk after the Kobe EQ.

The pre- and post-EQ trend estimated in Model 3 are summarized in Figure 5. The estimated coefficients are reported in the panels depending on the magnitude of the estimated coefficients. Consistent with Model 2, coefficients are significant at least 1% level in all post-EQ years, while none of income and savings terms are significant in the entire sample period (not reported in Figure 5). Post-EQ jumps are observed for all variables. The post-EQ trends did not revert to the pre-EQ level. All of these results not only confirm the post-EQ effects reported in Model 2 but also provides a quite different picture on the relationships between the economic and demographic factors and EQ insurance take-up. Models 2 and 3 clearly show that the relationships are substantially affected by the major EQ.

5.2. Effect of Loss Experience in Kobe EQ

We further investigate the impact of Kobe EQ by considering the loss experience of the EQ because the direct loss experience significantly affect risk perception (e.g., Kamiya and Yanase, 2018). It is reasonable to extend our investigation to how the severe loss experience would affect the relationship between economic and demographic factors and EQ insurance take-up.

To examine the effect, we adopt Equation (3) and the estimation results are reported in Table 5. All models include not only post-EQ interaction terms but also EQ measure interaction terms, which are designed to capture the marginal effect of loss experience. Specifically, Models 1 include the economic and demographic terms interacting with the post-quake damage dummy variable (Model 1), which equals one in the post-Kobe period if residential buildings in the prefectures suffered damage and zero otherwise (one variable for each of the four prefectures: Hyogo, Osaka, Kyoto and Tokushima). Model 2 replaces the dichotomous direct experience variable with the damage rate variable, which is defined as the percentage of households that suffered damage to their residential buildings (e.g., the largest value was 28% for the Hyogo Prefecture). In Models 3-5, we examine the effect of another individual's loss experience by using three EQ intensity measures. Intensity-level scale is defined from level 7 (maximum) to level 0.[27] In the Kobe EQ, the level 7 was recorded only in Hyogo, followed by the level 5 in two nearby prefectures, Kyoto and Shiga. Many neighbor prefectures recorded the level 4. Note that the recorded intensity levels are not perfectly correlated with the damage measures, but damaged prefectures are located closely to the epicenter and recorded at least the level 4. To investigate the seismic intensity effect, we construct intensity dummy variables. The first dummy variable equals to one if the intensity level is at least 6, 0 otherwise (Model 3), which is equivalent to an indicator variable for Hyogo Prefecture. Similarly, we define the intensity dummy variables with one if the intensity level is at least 5 or 4, 0 otherwise. These are included in Models 4 and 5.

Table 5 shows that the estimation results of the post-EQ socio-economic and demographic terms are mostly consistent with those in Table 4, indicating that the implication obtained in Table 5 still hold after including additional post-EQ intensity interaction terms. However, estimated coefficients for the EQ-intensity interaction terms vary between models. First, Model 1 which uses damage indicator variable as an EQ measure shows that only newspaper term is sensitive to the direct loss experience. The negative relationship between newspaper and insurance take-up during the post-EQ period may suggest that EQ information reduced overreaction after EQ experience. None of the EQ measure interaction terms are significant in Model 2. As noted above, Model 3 represents only Hyogo, the most severely damaged prefecture shows quite different results. The coefficient of the price interaction term is positive in Model 3 (Intensity level at least 6) but negative in Models 4 (Intensity level at least 5). The contrast suggests that the risk motivated increase in take-up was driven only by the severely damaged prefectures and that the price elasticity of demand dominates after two other affected prefectures are included. The income-severity interaction terms also support our hypothesis in that Model 3 show that the level of household income becomes positively related to take-up after their severe loss experience in the EQ. A 1% increase in income is associated with a 2.4% take-up increase in Hyogo. In contrast, the relationship becomes negative in Model 5, suggesting the post-EQ negative income effect in neighbor prefectures. The negative education effect may suggest that education reduced overreaction to the direct EQ experience in Models 3, whereas it is positive in Model 5. The conflicting signs explains that the impact of the EQ depends on the severity of loss experience. Another interesting finding is that education positively affects EQ insurance take-up only when individuals experience relatively large ground move (Model 5), which is also confirmed by insignificance of the post-EQ education interaction term in country average.

Given available data, we cannot conclude the reason of the difference in the prefectures with strong ground move, but we are able to confirm the determinants of EQ insurance take-up substantially affected after the Kobe EQ experience.

[27] The description of the intensity scale is available in Japanese http://www.jma.go.jp/jma/kishou/know/shindo/kaisetsu.html

5.3. Effect of Socio-Demographic Factors on EQ Insurance Take-Up after Tohoku EQ

Before discussing the estimation results for the period around the 2011 Tohoku EQ, we note that the EQ insurance market significantly developed after Kobe EQ. In FY1992 before Kobe EQ, the average density of EQ insurance (per household) was 4.7%, which has increased to 19.4% in FY 2009 before Tohoku EQ.[28] Several other EQs between the two mega EQs, which also increased EQ risk awareness. Thus, in the following analyses, we deal with a relatively developed market and intend to provide implication to such markets, though we employ the same empirical approach by focusing on EQ insurance take-up around the 2011 Tohoku EQ. However, the pre-Tohoku period is slightly noisy because intensity level-6 EQs occurred in 2006, 2007, and 2008 (two level-6 EQs in the Tohoku region), although the sample excludes prefectures that suffered from these EQs if they differed from those that severely suffered from the 2011 Tohoku EQ.

Consistent with the results for the Kobe EQ, the post-Tohoku surge in insurance take-up is confirmed in Table 6, although the increase is limited to 35% in the 4 years after the EQ (Model 1). The smaller effect on the growth of the take-up rate is reasonable, given the substantial increase of the take-up rate from Kobe EQ and following other major EQs. Model 1 also indicates that the number of primary policy, price, and JA insurance are significant determinants of EQ insurance take-up. The sensitivity of the size of potential market to EQ insurance take-up is 0.43, which is substantially smaller than that estimated in the Kobe EQ period (1.24) in Table 4, suggesting importance of other factors in the developed market. The magnitude of the price elasticity also becomes substantially smaller in this market (-0.15 in the developed market and -0.55 in the Kobe EQ period). Comparing the significant increase in the price elasticity of take-up after Kobe EQ, we find the effect has dropped substantially. The negative effect of JA insurance is probably due to market constraint which binds as market penetration of the EQ insurance increases.

Model 2 including the post-EQ interaction terms show that there are changes in the impact of the economic and demographic factors after Tohoku EQ. First, price has an additional marginal effect (-0.069) after the EQ, which is consistent with the post-Kobe period. We also find that newspapers and agents have a positive effect in the post-Tohoku period, which partially offsets their negative effect during the entire period. The role of information after Tohoku EQ is consistent with that after Kobe EQ, suggesting the information about a disaster help increase a take-up during a post-EQ period. In contrast, the positive effect of agent in the post-EQ period, different from the negative marginal effect after Kobe EQ, requires further investigation about the impact of market development and the role of distribution channels.

Table 7 includes post-EQ severity interaction terms to investigate the impact of loss experience and is comparable with Table 5 for Kobe EQ. A major difference from the post-Kobe take-up is that damage rates (i.e., the severity of direct loss experience) affect the determinants of take-up. First, the price elasticity of take-up was influenced in prefectures with direct loss experience (Models 2 and 3). The price-severity

[28] These levels of market penetrations do not represent the overall EQ insurance penetration in Japan because EQ insurance coverage offered by cooperatives are not included in this statistics.

interaction term suggests that severe loss experience increased take-up more in high risk regions. It is also shown that the proportion of savings is positively related to take-up of severely suffered regions, though it is not consistent with substitution effect. The education-severity interaction term is negative in Model 2, which is also consistent with the post-Kobe reaction in that education helps individuals to less overreact to their loss experience. The newspaper-severity interaction terms also provide evidence that a post-EQ effect depends on loss experience. In particular, Models 3 and 4 show a negative and significant effect of information by newspapers in damaged prefectures, though interpretation of the negative effect in suffered prefectures needs further investigation. Finally, the agent-intensity interaction terms also show that the number of insurance agents become less relevant to post-EQ take-up in prefectures with severe loss experience, while agents help increase take-up more on average in prefectures with greater intensities than the country average. Thus, the analyses for Tohoku EQ also shows that the determinants of EQ insurance take-up substantially affected after the EQ experience and the stage of market development.

6. Policy Implications

Pricing

It is interesting to observe that price of insurance is not a significant determinant of EQ insurance when the market is immature, confirmed by the pre-Kobe price elasticity of take-up. This is reasonable because only individuals who are relatively more risk conscious take risk mitigation behaviors. However, as more individuals start buying insurance, the price becomes an important determinant of insurance purchase in that the level of price is negatively related to the insurance take-up after both Kobe EQ and Tohoku EQ. More interestingly, the post-EQ price effect depends on the severity of loss experience. It is remarkable that the marginal price effect turns positive for those who experienced direct loss, i.e., strong ground move is not enough to see the positive relationship.

Under the simple rating scheme that results in significant cross-subsidization between policyholders (Naoi, Seko, and Sumita, 2010), the strong positive price elasticity of take-up would reflect rational decisions after experiencing direct loss experience. The reason is that the cross-subsidization between policyholders gives a discount to households living in high risk prefectures and would encourage those living in high risk regions to purchase catastrophe insurance, while it would discourage low risk households to purchase insurance.

As the market becomes matured, the strong and negative price sensitivity of take-up may require reconsideration of the simple rating scheme because households living in low risk regions may be giving up purchasing EQ coverage due to a premium rate subsidizing other policyholders.

Education/Information

Whether the level of education affects risk awareness or risk aversion, it helps promote EQ insurance take-up after a major EQ when insurance market is developing. However, direct loss experience makes a level of education irrelevant to take-up. The impact of direct loss experience may dominate the difference of educational background. After the market matured, we no longer observe the effect of education on take-up expect for its negative effect of damage rate, indicating that education reduces post-EQ reaction, possibly overreaction, to severe direct loss experience.

Media plays an important role for post-EQ increase of take-up of those who did not experience direct loss, while for those who experienced direct loss, information from media does not help them to update their beliefs. The results for information and education indicate that the key of promoting insurance take-up is to increase risk perception and risk mitigation behavior of those who did not experience direct loss. Individuals are responsive to the new information and updated their risk beliefs after the extreme EQ. Fear from the information would increase risk perception as well. Thus, timing may be critical for insurers and policymakers to promote catastrophe insurance coverage.

Insurance Agents

One the contrary to our prediction, the sales force becomes less relevant to EQ insurance take-up through the post Kobe period, while there is a sign that it helped increase take-up in prefectures with strong ground move. When the market matured, we observe a reverse relationship, i.e., the sales force turned to be a determinant after a major EQ.

Overall, our EQ insurance sample shows that direct and indirect loss experience of major EQs provide years of opportunities that individuals could update their risk beliefs and EQ insurance take-up was driven by demand side effects. Unfortunately, such opportunities would not arise without severe loss experience. Insurers and policymakers may capitalize on such opportunities by preparing their marketing strategies and implement the plan in a proper timing.

Such strategic approach of promoting catastrophe insurance may be useful for the market struggling to increase take-up rate such as California earthquake insurance offered by CEA and The National Flood Insurance Program (NFIP) in US. Especially, the take-up rate of NFIP policy surged after major floods, though the increase is only temporary, suggesting that households are certainly reactive to a direct and indirect loss experience, i.e., their risk beliefs are updated upon an arrival of new flood information. To maintain the updated belief, flood risk information should be timely distributed through media to help households to make informed decisions on flood risk mitigation.

7. Conclusion

Using Japanese data on the purchases of residential earthquake insurance, we test hypotheses concerning how an experience of a major EQ would affect the relationship between economic and demographic factors and how the severity of loss experience would marginally change the relationship as well. Our empirical tests support the hypotheses and we find several important implications of catastrophe insurance take-up. First, how economic and demographic factors affect catastrophe insurance take-up may depend on the development of insurance market. When the market is relatively new or still has a low penetration, the level of price may not be a determinant of take-up, i.e., cross-subsidization aiming level premium rates may not achieve its purpose. Second, whether direct or indirect loss experience, an occurrence of a major catastrophe strongly encourages households to buy insurance. However, a key of increasing take-up is to maintain updated risk beliefs in the post-catastrophe period. Insurers and policymakers may prepare a strategic plan to educate consumers and to let them make informed decision on insurance purchase.

We also show that the post-catastrophe effect of social-economic and demographic factors depends on the severity of loss experience. Direct loss of a major catastrophe seems overwhelming so that the factors tend to be less relevant to decision making of insurance purchase.

Regardless of the findings, we note that our results are based on prefecture-level aggregate data for Japanese EQ insurance take-up. Earthquake risk is quite different from other perils such as flood risk and wind risk. Also, aggregate data have limitation in deriving implication. It is strongly encouraged to investigate validity of our findings in individual data.

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Figure 1: Epicenters of the 1995 Hanshin EQ and the 2011 Tohoku EQ

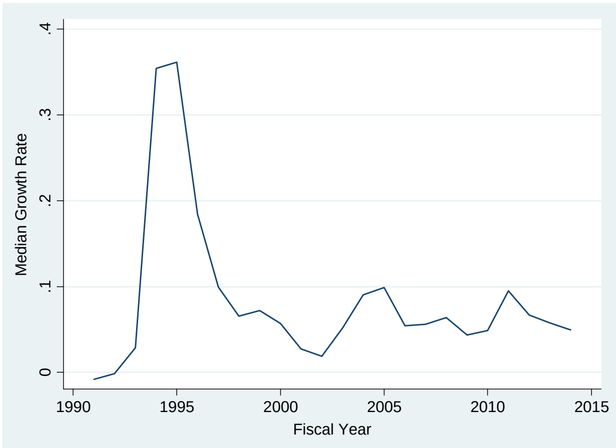

Figure 2: Median Growth of Japanese Residential Earthquake Insurance Take-up Rates

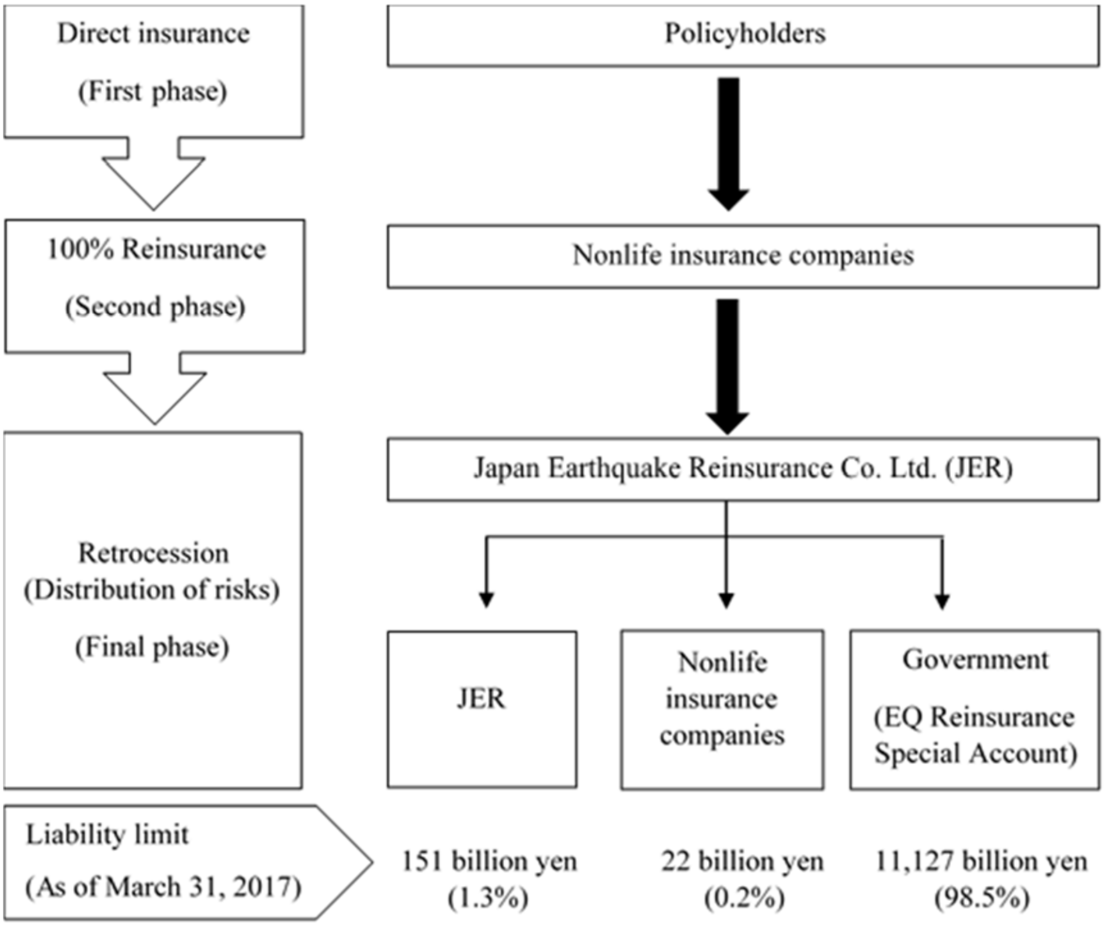

Figure 3: Standardization and Distribution of Risks in the EQ Insurance

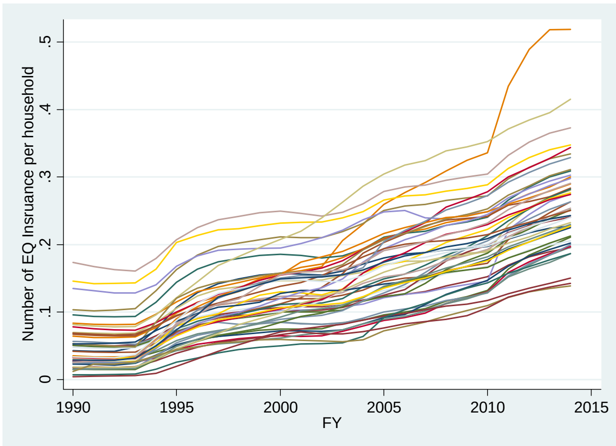

Figure 4: Earthquake Insurance Take-up Rate by Prefectures

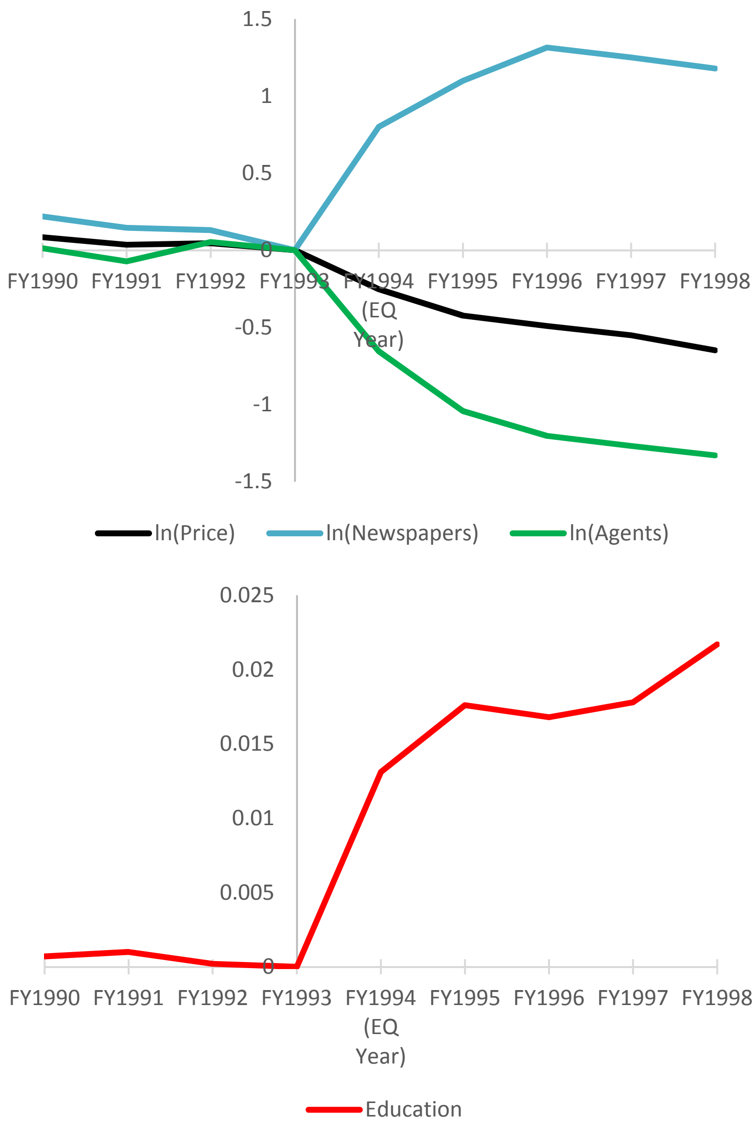

Figure 5: Post-Kobe Marginal Effects of Economic and Demographic Factors

Table 1 Definition of Variables

Variable	Definition	Source
Dependent variables		
EQ Insurance	Number of EQ insurance coverage insured (in force) per household	General Insurance Rating Orgainization of Japan (GIROJ) (http://www.giroj.or.jp)
Explanatory variables		
Fire Insurance	Number of fire insurance coverage written per household	GIROJ
Price	EQ insurance average premium rate per 1000 yen	GIROJ
Income	Average monthly disposable income per household (1 million yen)	Statistics Bureau of Japan (http://www.stat.go.jp)
Savings	Percentage of monthly household savings	Statistics Bureau of Japan
Newspaper	Number of newspapers per household	Nihon Sinbun Kyokai (http://www.pressnet.or.jp)
Education	Percentage of students admitted to college education	Ministry of Education, Culture, Sports, Science and Technology (http://www.mext.go.jp)
JA Insurance	Number of JA home insurance policies per household	National Mutual Insurance Federation of Agricultural Cooperatives (http://www.ja-kyosai.or.jp)
Agent	Number of insurance agent per households	Hoken Kenkyujo (http://www.hoken-kenkyujo.co.jp)
EQ Intensity Variables		
Damage	One if there is damaged residential buildings, and zero otherwise	Fire and Disaster Management Agency of Japan (FDMA) (http://www.fdma.go.jp/)
Damage Rate	Number of damaged residential buildings per household	FDMA
Intensity Level 4	EQ intensity level 4 and above	FDMA
Intensity Level 5	EQ intensity level 5 and above	FDMA
Intensity Level 6	EQ intensity level 6 and above	FDMA

Table 2 Summary Statistics

	Obs.	Mean	S.D.	Minimum	5 pctl	50 pctl	95 pctl	Maximum
FY1990-2014 Sample Period								
EQ Insurance	1175	0.141	0.082	0.005	0.026	0.130	0.285	0.519
Fire Insurance	1175	0.087	0.027	0.024	0.046	0.086	0.137	0.192
Price	1175	1.419	0.572	0.750	0.750	1.238	2.640	3.025
Income	1175	0.462	0.059	0.302	0.369	0.462	0.562	0.728
Savings	1175	18.515	6.125	-2.108	7.933	18.931	28.368	36.883
Education	1175	43.086	9.333	19.400	27.200	43.100	58.200	67.000
Newspaper	1175	1.072	0.219	0.237	0.769	1.087	1.327	5.294
JA Insurance	1175	0.400	0.208	0.032	0.062	0.383	0.787	0.946
Agent	1175	0.007	0.005	0.001	0.003	0.006	0.012	0.110
FY1990-1998 Sample Period								
EQ Insurance	423	0.073	0.047	0.005	0.017	0.064	0.167	0.242
Fire Insurance	423	0.101	0.028	0.025	0.056	0.100	0.154	0.192
Price	423	1.519	0.532	0.913	0.913	1.350	2.788	3.025
Income	423	0.482	0.058	0.302	0.383	0.483	0.575	0.728
Savings	423	19.25	5.278	-2.108	11.13	19.09	28.14	32.24
Education	423	35.69	7.339	19.40	23.70	35.30	47.30	54.10
Newspaper	423	1.175	0.137	0.816	0.907	1.190	1.362	1.475
JA Insurance	423	0.470	0.230	0.032	0.064	0.464	0.818	0.946
Agent	423	0.009	0.002	0.004	0.006	0.008	0.012	0.019
FY2006-2014 Sample Period								
EQ Insurance	423	0.212	0.070	0.079	0.106	0.208	0.329	0.519
Fire Insurance	423	0.076	0.020	0.024	0.043	0.075	0.110	0.126
Price	423	1.287	0.616	0.750	0.750	0.960	2.410	2.650
Income	423	0.435	0.050	0.304	0.356	0.437	0.523	0.625
Savings	423	17.63	6.498	0.224	5.685	18.30	27.72	36.13
Education	423	50.01	7.090	33.50	39.90	50.60	61.20	67.00
Newspaper	423	0.956	0.277	0.237	0.688	0.953	1.160	5.294
JA Insurance	423	0.314	0.149	0.034	0.051	0.323	0.546	0.735
Agent	423	0.004	0.001	0.002	0.003	0.004	0.006	0.007
1995 Kobe EQ								
Damage	47	0.085	0.282	0	0	0	1	1
Damage Rate	47	0.007	0.041	0	0	0	0.001	0.282
Intensity Level 4	47	2.404	1.677	0	0	2	5	7
Intensity Level 5	47	0.207	0.130	0.125	0.125	0.167	0.333	1
Intensity Level 6	47	0.388	0.100	0.325	0.325	0.358	0.477	1
2011 Tohoku EQ								
Damage	47	0.404	0.496	0	0	0	1	1
Damage Rate	47	0.027	0.092	0	0	0	0.192	0.516
Intensity Level 4	47	3.340	1.926	0	1	3	6	7
Intensity Level 5	47	0.272	0.164	0.125	0.143	0.200	0.500	1
Intensity Level 6	47	0.433	0.121	0.325	0.339	0.383	0.591	1

Table 3 Earthquake in Japan

Intensity Level	Frequency (per year)
1	1,871.91
2	736.13
3	225.09
4	61.43
5-	8.13
5+	2.87
6-	1.30
6+	0.48
7	0.13
Total	2,907.47

Table 4: Kobe EQ Effect on the Relationship between Socio-Demographic Factors and EQ Insurance Take-Up

This table shows how the 1995 Kobe EQ affected the relationship between economic and demographic factors and EQ insurance take-up during the the sample period of 1990-1998. The dependent variables are the natural log of the number of EQ Insurance coverage per household. All models include constant, year fixed effects, prefecture fixed effects, and socio-demographic variables. Year dummies for the prior year of Kobe EQ is excluded as a reference year. Model 2 includes post-EQ interaction terms between a post-EQ (1994-98) indicator and socio-demographic variables. Model 3 includes interaction terms between year indicaters and socio-demographic variables. See Table 1 for the definition of the variables. The sample excludes prefectures that suffered direct loss from other EQs during the sample period. Results shown are from OLS regressions. ***, **, and * denote significance at the 1% level, 5% level, and 10% level by heteroskedasticity and cluster robust standard errors.

	(1)	(2)	(3)
ln(Fire Insurance)	1.2381**	0.9370**	0.7830
	(0.5565)	(0.4470)	(0.4710)
ln(Price)	-0.5520**	-0.0540	0.0001
	(0.2428)	(0.1785)	(0.1773)
ln(Income)	0.1312	-0.0468	-0.0738
	(0.2640)	(0.2564)	(0.2599)
savings	-0.0024	0.0012	0.0009
	(0.0021)	(0.0030)	(0.0032)
Education	-0.0236	-0.0133	-0.0128
	(0.0165)	(0.0115)	(0.0115)
ln(Newspaper)	-0.6283	-1.3264*	-1.2817
	(1.1246)	(0.7764)	(0.7753)
ln(JA Insurance)	0.9091	1.0847*	1.1480**
	(0.8266)	(0.5540)	(0.4922)
ln(Agents)	0.6834	1.3074***	1.2351***
	(0.6714)	(0.3925)	(0.3474)
FY1990	0.1193	0.0834	0.0650
	(0.1143)	(0.0897)	(0.0888)
FY1991	0.0018	0.0464	0.0413
	(0.0673)	(0.0486)	(0.0478)
FY1992	-0.0234	-0.0078	-0.0096
	(0.0377)	(0.0263)	(0.0257)
FY1994 (Kobe EQ Year)	0.3404***	-5.3361***	-2.9653***
	(0.0476)	(1.0681)	(0.7549)
FY1995	0.6505***	-5.0517***	-4.5079***
	(0.0803)	(1.0646)	(1.2211)
FY1996	0.6422**	-4.9426***	-5.6180***
	(0.2454)	(1.0616)	(1.2724)
FY1997	0.7760***	-4.8574***	-5.8100***
	(0.2366)	(1.0674)	(1.1995)
FY1998	0.9055***	-4.7646***	-5.7056***
	(0.2542)	(1.0738)	(1.2054)
Post interaction terms			
ln(Price)*Post	-	-0.4809***	**Reported in Figure 5**
	-	(0.0991)	
ln(Income)*Post	-	0.1674	
	-	(0.3490)	
Savings*Post	-	-0.0045	
	-	(0.0041)	
Education*Post	-	0.0163***	
	-	(0.0046)	
ln(Newspapers)*Post	-	1.0684***	
	-	(0.3871)	
ln(Agents)*Post	-	-1.0754***	
	-	(0.2000)	
Observations	396	396	396
Adjusted R-squared	0.8839	0.9354	0.9447
Perfecture FE	Yes	Yes	Yes

Table 5: Kobe EQ Loss Experience Effect on Socio-Demographic Factors

This table shows how experience of the 1995 Kobe EQ affected the relationship between economic and demographic factors and EQ insurance take-up during the the sample period of 1990-1998. The dependent variables are the natural log of the number of EQ Insurance coverage per household. All models include constant, year fixed effects, prefecture fixed effects, socio-demographic variables, and post-EQ (1994-98) terms interacting with socio-demographic variables. Year dummies for the prior year of Kobe EQ is excluded as a reference year. Models 1 and 2 includes damage dummy and damage rate terms interacting with socio-demographic variables. Models 3-5 include EQ Intensity dummy terms interacting with socio-demographic variables. See Table 1 for the definition of the variables. The sample excludes prefectures that suffered direct loss from other EQs during the sample period. Results shown are from OLS regressions. ***, **, and * denote significance at the 1% level, 5% level, and 10% level by heteroskedasticity and cluster robust standard errors.

	(1)	(2)	(3)	(4)	(5)
ln(Fire Insurance)	1.1010***	1.2192***	1.1736**	1.0173**	0.9750***
	(0.3970)	(0.4333)	(0.4360)	(0.4056)	(0.3200)
ln(Price)	-0.0420	-0.0659	-0.0638	-0.0529	-0.0738
	(0.1753)	(0.1767)	(0.1804)	(0.1758)	(0.1498)
ln(Income)	-0.2283	-0.1853	-0.1530	-0.1991	-0.1907
	(0.2467)	(0.2538)	(0.2483)	(0.2440)	(0.2508)
savings	0.0004	0.0006	0.0003	-0.0008	0.0017
	(0.0030)	(0.0030)	(0.0030)	(0.0028)	(0.0028)
Education	-0.0164	-0.0125	-0.0122	-0.0171	-0.0085
	(0.0120)	(0.0117)	(0.0117)	(0.0121)	(0.0121)
ln(Newspaper)	-1.0279	-1.1314	-1.2000	-1.2175	-1.2143
	(0.7487)	(0.7826)	(0.7874)	(0.7298)	(0.7320)
ln(JA Insurance)	0.8992	0.9317	0.9865*	1.1606**	1.1664**
	(0.6266)	(0.5859)	(0.5574)	(0.4941)	(0.5413)
ln(Agents)	1.2870***	1.3041***	1.3260***	1.2093***	1.2162***
	(0.3850)	(0.3694)	(0.3680)	(0.3696)	(0.3662)
Post EQ	0.0257	0.0610	0.0708	0.0391	0.0795
	(0.0973)	(0.0946)	(0.0915)	(0.0886)	(0.0817)
Post interaction terms					
ln(Price)*Post	-0.4894***	-0.4661***	-0.4647***	-0.5177***	-0.5603***
	(0.1018)	(0.1021)	(0.1014)	(0.0967)	(0.1109)
ln(Income)*Post	0.2486	0.1877	0.1601	0.1693	0.5641*
	(0.3548)	(0.3515)	(0.3487)	(0.3486)	(0.3223)
Savings*Post	-0.0027	-0.0031	-0.0031	-0.0024	-0.0022
	(0.0041)	(0.0040)	(0.0039)	(0.0041)	(0.0034)
Education*Post	0.0139***	0.0139***	0.0139***	0.0118**	0.0098
	(0.0050)	(0.0047)	(0.0047)	(0.0047)	(0.0059)
ln(Newspaper)*Post	0.9618**	1.0523**	1.1034***	0.9970**	0.3674
	(0.4165)	(0.3951)	(0.3828)	(0.3944)	(0.4350)
ln(Agents)*Post	-0.9995***	-1.0460***	-1.0587***	-0.9021***	-0.7825***
	(0.2060)	(0.2019)	(0.2001)	(0.1831)	(0.1871)
EQ interaction terms	**Damage D**	**Damage Rate**	**Intensity Level ≥ 6**	**Intensity Level ≥ 5**	**Intensity Level ≥ 4**
Post*EQ measure	-0.2074	-140.9028	0.6178	10.8800**	-3.7028***
	(1.0971)	(322.2640)	(0.6067)	(4.4240)	(0.9225)
ln(Price)*Post*EQ measure	1.3470***	129.7241	3.2867***	-4.6756*	0.2162
	(0.2048)	(226.0729)	(0.7251)	(2.7614)	(0.1691)
ln(Income)*Post*EQ measure	0.0980	46.4687	2.4327***	1.6744***	-0.8820**
	(0.4815)	(46.8502)	(0.7051)	(0.5371)	(0.4101)
Savings*Post*EQ measure	-0.0026	-0.3164	-0.0020	-0.0064	-0.0061
	(0.0050)	(0.4842)	(0.0046)	(0.0041)	(0.0049)
Education*Post*EQ measure	-0.0128	-0.4862	-0.0180*	0.0076	0.0278***
	(0.0064)	(0.5827)	(0.0098)	(0.0130)	(0.0080)
ln(Newspaper)*Post*EQ measure	-2.1071***	54.9752	-	1.3669	1.0654**
	(0.5756)	(56.1091)		(1.7800)	(0.4806)
ln(Agents)*Post*EQ measure	-0.1354	-21.8198	-	1.3645**	-0.3875**
	(0.1626)	(46.6981)		(0.6245)	(0.1494)
Observations	396	396	396	396	396
Adjusted R-squared	0.9399	0.9385	0.9381	0.9457	0.9490
Perfecture FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Table 6: Tohoku EQ Effect on the Relationship between Socio-Demographic Factors and EQ Insurance Take-Up

This table shows how the 2011 Tohoku EQ affected the relationship between economic and demographic factors and EQ insurance take-up during the the sample period of 2006-2014. The dependent variables are the natural log of the number of EQ Insurance coverage per household. All models include constant, year fixed effects, prefecture fixed effects, and socio-demographic variables. Year dummies for the prior year of Tohoku EQ is excluded as a reference year. Model 2 includes post-EQ (2011-14) terms interacting with socio-demographic variables. See Table 1 for the definition of the variables. The sample excludes prefectures that suffered direct loss from other EQs during the sample period. Results shown are from OLS regressions. ***, **, and * denote significance at the 1% level, 5% level, and 10% level by heteroskedasticity and cluster robust standard errors.

	(1)	(2)
ln(Fire Insurance)	0.4323***	0.3599***
	(0.1292)	(0.0925)
ln(Price)	-0.1533***	-0.0844***
	(0.0219)	(0.0221)
ln(Income)	0.0610	0.0039
	(0.0544)	(0.0819)
savings	0.0004	-0.0015*
	(0.0006)	(0.0008)
Education	-0.0056	0.0087
	(0.0058)	(0.0060)
ln(Newspaper)	0.0012	-0.2208**
	(0.0129)	(0.0834)
ln(JA Insurance)	-0.5447**	-0.4164**
	(0.2359)	(0.2036)
ln(Agents)	-0.1905	-0.3168*
	(0.1920)	(0.1724)
FY2006	0.2007**	-0.9545**
	(0.0988)	(0.3745)
FY2007	-0.0515	-1.1776***
	(0.0455)	(0.2174)
FY2008	-0.0493**	-0.5195***
	(0.0229)	(0.1624)
FY2010 (Tohoku EQ Year)	0.0672***	0.0300
	(0.0208)	(0.2058)
FY2011	0.1635***	0.2078
	(0.0354)	(0.2187)
FY2012	0.2092***	0.6970*
	(0.0437)	(0.3490)
FY2013	0.2577***	0.7074**
	(0.0515)	(0.3490)
FY2014	0.3536***	0.7522*
	(0.0559)	(0.4352)
Post interaction terms		
ln(Price)*Post		-0.0689***
		(0.0213)
ln(Income)*Post		-0.0158
		(0.0912)
Savings*Post		0.0011
		(0.0010)
Education*Post		-0.0031
		(0.0020)
ln(Newspaper)*Post		0.1790**
		(0.0699)
ln(Agents)*Post		0.1276***
		(0.0435)
Observations	387	387
Adjusted R-squared	0.9021	0.9305
Perfecture FE	Yes	Yes
Year FE	Yes	Yes

Table 7: Tohoku EQ Loss Experience Effect on Socio-Demographic Factors

This table shows how experience of the 2011 Tohoku EQ affected the relationship between economic and demographic factors and EQ insurance take-up during the the sample period of 2006-2014. The dependent variables are the natural log of the number of EQ Insurance coverage per household. All models include constant, year fixed effects, prefecture fixed effects, socio-demographic variables, and post-EQ (2010-1014) terms interacting with socio-demographic variables. Year dummies for the prior year of Tohoku EQ is excluded as a reference year. Models 1 and 2 includes damage dummy and damage rate terms interacting with socio-demographic variables. Models 3-5 include EQ Intensity dummy terms interacting with socio-demographic variables. See Table 1 for the definition of the variables. The sample excludes prefectures that suffered direct loss from other EQs during the sample period. Results shown are from OLS regressions. ***, **, and * denote significance at the 1% level, 5% level, and 10% level by heteroskedasticity and cluster robust standard errors.

	(1)	(2)	(3)	(4)	(5)
ln(Fire Insurance)	0.3091***	0.2434***	0.2545***	0.2385***	0.3167***
	(0.0960)	(0.0841)	(0.0892)	(0.0870)	(0.0978)
ln(Price)	-0.0982***	-0.1018***	-0.1003***	-0.0933***	-0.0989***
	(0.0240)	(0.0241)	(0.0243)	(0.0238)	(0.0242)
ln(Income)	0.0262	0.0246	0.0346	0.0289	0.0160
	(0.0800)	(0.0777)	(0.0801)	(0.0853)	(0.0763)
savings	-0.0003	-0.0007	-0.0006	-0.0004	-0.0003
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Education	0.0022	-0.0018	-0.0007	-0.0025	0.0020
	(0.0044)	(0.0039)	(0.0037)	(0.0039)	(0.0041)
ln(Newspaper)	-0.1783**	-0.1522**	-0.1757***	-0.1573**	-0.1773**
	(0.0744)	(0.0623)	(0.0648)	(0.0707)	(0.0732)
ln(JA Insurance)	-0.4166*	-0.3841*	-0.3062	-0.0457	-0.4307
	(0.2468)	(0.1927)	(0.1996)	(0.2026)	(0.2827)
ln(Agents)	-0.4374**	-0.4489***	-0.4261**	-0.4024**	-0.4998***
	(0.1665)	(0.1566)	(0.1601)	(0.1505)	(0.1668)
Post EQ	0.2052**	0.1521**	0.1479**	0.0910	0.2240**
	(0.0892)	(0.0640)	(0.0706)	(0.0731)	(0.0967)
Post interaction terms					
ln(Price)*Post	-0.0703**	-0.0780***	-0.0769***	-0.0823***	-0.0692***
	(0.0269)	(0.0211)	(0.0215)	(0.0210)	(0.0206)
ln(Income)*Post	-0.0902	-0.0547	-0.0572	-0.0961	-0.0877
	(0.0970)	(0.0878)	(0.0932)	(0.1003)	(0.0934)
Savings*Post	0.0007	0.0008	0.0008	0.0009	0.0010
	(0.0009)	(0.0010)	(0.0010)	(0.0011)	(0.0011)
Education*Post	-0.0017	-0.0015	-0.0015	-0.0004	-0.0012
	(0.0025)	(0.0020)	(0.0020)	(0.0025)	(0.0025)
ln(Newspaper)*Post	0.1761**	0.1537**	0.1764***	0.1546**	0.1746**
	(0.0712)	(0.0634)	(0.0644)	(0.0683)	(0.0711)
ln(Agents)*Post	0.1136*	0.1268***	0.1200**	0.1611***	0.1483***
	(0.0621)	(0.0414)	(0.0478)	(0.0520)	(0.0503)
EQ interaction terms	**Damage D**	**Damage Rate**	**Intensity Level ≥ 6**	**Intensity Level ≥ 5**	**Intensity Level ≥ 4**
Post*EQ measure	0.3530	-19.9182***	1.2931**	0.7734	0.8010
	(0.4881)	(5.6862)	(0.5918)	(0.4671)	(0.5113)
ln(Price)*Post*EQ measure	-0.0285	0.7224***	0.0506*	0.0270	0.0264
	(0.0389)	(0.1405)	(0.0297)	(0.0320)	(0.0338)
ln(Income)*Post*EQ measure	0.1101	0.8088	0.0425	0.2659*	0.1989
	(0.1410)	(0.5700)	(0.1606)	(0.1516)	(0.1332)
Savings*Post*EQ measure	0.0016	0.0154***	0.0014	-0.0010	-0.0006
	(0.0017)	(0.0046)	(0.0009)	(0.0014)	(0.0015)
Education*Post*EQ measure	-0.0013	-0.0828***	-0.0058	-0.0070*	-0.0045
	(0.0034)	(0.0197)	(0.0047)	(0.0038)	(0.0036)
ln(Newspaper)*Post*EQ measure	-0.1026	-0.1344	-0.5381***	-0.4088***	-0.2654
	(0.1713)	(0.6178)	(0.1531)	(0.1417)	(0.1808)
ln(Agents)*Post*EQ measure	0.0366	-4.5361***	0.1809*	0.0292	0.0738
	(0.0954)	(1.0683)	(0.1066)	(0.0730)	(0.0917)
Observations	387	387	387	387	387
Adjusted R-squared	0.9338	0.9507	0.9439	0.9427	0.9366
Perfecture FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes