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Consumption Insurance and Risk-Coping Strategies under Non-Separable Utility: Evidence from the Kobe Earthquake

Yasuyuki Sawada
University of Tokyo

Satoshi Shimizutani
Institute for International Policy Studies (IIPS)

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by

Yasuyuki Sawada♦

Faculty of Economics, University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
Email: sawada@e.u-tokyo.ac.jp

and

Satoshi Shimizutani

Institute for International Policy Studies (IIPS)
Toranomon 30 Mori Bldg., 6F, Toranomon 3-2-2
Minato-ku, Tokyo 105-0001 JAPAN
Email: sshimizutani@hotmail.com

Abstract

Using a unique household-level dataset on the situation after the Kobe earthquake in 1995, we test the full consumption risk sharing hypothesis, relaxing the separability assumption, and examine households' simultaneous choice of risk coping measures. Using multivariate probit estimations, we find that the full consumption insurance hypothesis is strongly rejected and our results indicate that households' utility across different expenditure items is not separable. As for households' choice of risk-coping measures, households borrowed extensively against housing damage, but relied on dissaving to cope with smaller asset damage, implying a hierarchy of risk-coping measures from dissaving to borrowing.

JEL codes: D12, D52; E21
Keywords: Natural disasters; Consumption risk-sharing; Risk-coping strategies; Earthquake

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♦ Corresponding author. Phone: +81-3-5841-5572; Fax: +81-3-5841-5521

1. Introduction

Natural disasters take place in both developed and developing countries and their number has been continuously increasing over the last fifty years [EM-DAT (2007)]. In the past few years alone, there have been several major disasters that resulted in tremendous human and economic losses, including the Asian tsunami in 2004, Hurricane Katrina in 2005, and the earthquakes in Pakistan and Indonesia in 2005. Japan, too, has suffered severe natural disasters and probably is more at risk, especially from earthquakes, than many other countries. During the twentieth century, Japan experienced a considerable number of large earthquakes – defined as earthquakes registering five or more points on the Richter scale – in a variety of regions: there were a total 32 such earthquakes during the first half of the century and 35 during the second half. In addition, since 2001 alone, Japan has experienced more than 11 large earthquakes. Of these large earthquakes, the Great Kanto earthquake in 1923, striking the area that includes Tokyo, caused the greatest human loss, claiming about 100,000 lives, but in terms of the economic damage caused measured in monetary loss, the Great Hanshin Awaji earthquake (hereafter, the Kobe earthquake) was the largest.

The Kobe earthquake struck at 5:46 a.m. on January, 17, 1995, hitting an area that contains one of Japan's main industrial clusters as well as major shipping ports and is home to 4 million people. The earthquake, which had registered 7.3 on the Richter scale, cost 6,432 lives (excluding 3 missing persons), resulted in 43,792 injured, and damaged 639,686 buildings, of which 104,906 were completely destroyed [Fire and Disaster Management Agency (2006)]. Together with Hurricane Katrina, the Kobe earthquake was responsible for the largest economic damage due to natural disaster in history: the loss in housing property amounted to more than

US$60 billion, while that in capital stock exceeded US$100 billion [Horwich (2000)]. The purpose of this study is to examine the effects of a large disaster on people's economic behavior in the affected area utilizing a unique household-level dataset collected from the Kobe area shortly after the earthquake. First, we explore whether households in the affected areas succeed in smoothing consumption in face of the disaster. Second, we investigate how people in the area utilized risk-coping measures to mitigate changes in consumption. While most previous studies have examined these issues separately, we adopt an integrated approach, examining both of the success and/or failure of consumption smoothing and the determinants of what risk-coping strategies are adopted in the face of a variety of unexpected shocks.

In order to address these issues, we perform two sets of analyses in our paper. First, we test the full consumption insurance hypothesis, or equivalently, full consumption risk sharing hypothesis to determine whether people in the Kobe area succeeded in smoothing their consumption. We extend the empirical strategy of Cochrane (1991) and Mace (1991) to the case of a non-separable utility function across multiple goods. Our analysis shows that the full risk-sharing hypothesis is strongly rejected and people in the affected area did not succeed in consumption smoothing, which suggests that formal and/or informal insurance mechanisms to cope with an earthquake were ineffective. Moreover, we reject the separability hypothesis across ten different expenditure items. Second, we examine which of a wide variety of formal and informal insurance mechanisms is adopted against earthquake using the framework developed by Fafchamps and Lund (2003). We compare three different risk-coping strategies: dissaving, borrowing, receiving transfers from private and public sources. We found that the risk-coping means are specific to the nature of the loss caused by the earthquake. Households borrow extensively to compensate for housing damage but rely on dissaving to compensate for damage to other assets. Transfers are likely to be effective against mild shocks and adopted particularly by multi-generation households.

By performing these analyses, we attempt to contribute to the rich existing literature on consumption insurance and households' risk coping strategies as well as to policy debates on disaster management in three aspects. First, most existing studies have not utilized natural disasters to test the full consumption risk sharing model. Since natural disasters cause exogenous shocks to households and are in most cases unexpected, empirical investigations are less hampered by econometric problems than studies using other episodes. As a natural experiment, an earthquake provides an unusual opportunity to identify market completeness and households' responses to an exogenous event [Rosenzweig and Wolpin (2000)]. Most previous studies that have tested the full consumption insurance model, such as Mace (1991), Cochrane (1991), Hayashi et al. (1996), and Townsend (1994), employed income changes, information on illness, involuntary job loss, and strikes as shock variables, which are not perfectly exogenous to households' decisions, resulting in a possible estimation bias due to measurement errors and endogeneity [Ravallion and Chaudhuri (1997)]. The merit of exploring natural disaster events is reinforced by the natural assumption that the Kobe earthquake was entirely unexpected. One of the reasons why the disaster was unexpected is that it has been almost a millennium since a comparable earthquake took place in the Kansai region, where Kobe is located [Horwich (2000)]. That people in the Kobe area did not anticipate the disaster is also evident from the fact that only 3% of the properties in Hyogo Prefecture were covered by earthquake insurance.[1] According to prefectural level information on earthquake insurance payments after the Kobe earthquake, Japan Agriculture (JA) was the dominant insurance provider in Hyogo Prefecture, the prefecture in which the Kobe area is located. This means that most of those who had earthquake insurance were full-time or part-time farmers. Since the Kobe earthquake hit the urban center, the number of those in the affected areas who had earthquake insurance was very small.

Second, the traditional full consumption risk sharing model assumes that information is publicly available [Mace (1991); Cochrane (1991); Hayashi et al. (1996); Townsend (1994); Simizutani (2003)]. However, this assumption is unrealistic and the income and other shock variables in existing studies are likely to be private information rather than public knowledge; it is therefore difficult to justify one of the main assumptions used to derive theoretically the full risk-sharing model [Ligon (1998)]. In contrast, the housing and asset damages caused by a disaster are more likely to be known to everyone and the magnitude of the damage is measured in a uniform formula employed by local governments to issue formal certificates for housing damage. Thus, the shocks that we use in this paper to examine the economic effects on households are more appropriate for testing the full consumption risk sharing hypothesis.

Third, we explicitly assume non-separability across different expenditure items and risk coping strategies. Most previous studies on full consumption risk sharing tests heavily depend on the assumption of separability but this assumption is rarely examined [Mace (1991)]. An exception is a study by Attanasio and Weber (1995), which shows that considering particular consumption items in isolation can yield very misleading results. Moreover, the separability assumption may be even more problematic in the case of an extraordinary shock, such as one caused by an earthquake, since such a large shock might substantially alter household preferences across goods and affect households' consumption of different items simultaneously, not separately. Our model allows us to test the validity of the separability assumption of the utility function by employing a multivariate probit model which considers the simultaneity of expenditure decisions on different items or of different coping devices. Our findings show that the assumption of separability is overwhelmingly violated.

In addition to examining consumption smoothing and the choice of risk coping strategies, we also aim to contribute to the policy debate on the effective management of risks induced by natural disasters. Since governments' role can be limited to compensating for the large losses caused by natural disasters, it is important to inform policy makers of how efficiently people cope with earthquake damage by themselves. Notably, in spite of the tremendous damage, economic recovery in the Kobe area was much faster than initially expected [Horwich (2000)]. Accordingly, lessons from the "success" in the wake of the Kobe earthquake may be crucial for designing appropriate policies to deal with future natural disasters both in developed and developing countries experiencing frequent natural disasters.

Although this study is not the first to examine the effects of the Kobe earthquake, we would like to emphasize that our studies differs from earlier ones in two important respects. First, there has been little research on the full consumption insurance hypothesis that considers the non-separability of goods in the context of a natural disaster. Kohara et. al. (2006) rejected the full consumption insurance hypothesis in the case of the Kobe earthquake, but they did not take into account the direct losses of each household.[2] In a previous paper [Sawada and Shimizutani (2007a)], we used the same dataset as this study to examine the full insurance hypothesis employing an ordered probit model but did not consider non-separability across multiple goods. In contrast, we test the full consumption risk sharing hypothesis with a non-separable utility function.

Second, we explicitly investigate the reason behind the strong rejection of the full consumption risk sharing hypothesis and examine the relative effectiveness of various risk-coping devices against sudden natural disasters., The use of earthquake data differentiate

[2] Furthermore, Kohara et. al. (2006) did not examine households' risk coping devices.

our study from most previous studies which deal with household responses to general shocks. Moreover, to our knowledge, few studies have employed household-level data in order to investigate jointly and quantitatively the role of savings, borrowing, and other risk-coping devices [Rosenzweig (2001)]. An exception is a study by Fafchamps and Lund (2003), who investigated the joint determination of risk-coping strategies in the rural Philippines, and we take a similar approach to theirs to examine households' choice of risk-coping strategy against a natural disaster. In another paper using the same data set [Sawada and Shimizutani (2007b)], we examined the determinants of mutual insurance mechanism through borrowing and private transfers separately, mainly focusing on the difference between borrowing-constrained and non-constrained households. However, the paper does not address the joint determination of risk-coping strategies, nor does it consider self insurance (dissaving). This prevented us from examining the choice of risk coping device under non-separability. We bridge this gap in the previous studies by employing a general model which nests both separable and non-separable cases.

The remainder of this paper is organized as follows. Section 2 presents the theoretical model employed in this study, while Section 3 provides a brief overview of the data set. In Section 4, we explain the empirical specifications and the estimation results of the full consumption insurance model. The estimation results of the determinants of risk-coping strategies are provided in Section 5 which is followed by concluding remarks in Section 6.

2. The Theoretical Framework

Households have developed formal and informal risk-coping mechanisms to deal with a wide variety of shocks in their day-to-day lives [Besley (1995); Fafchamps (2003); Fafchamps and Lund (2003); Townsend (1994)]. Such risk-coping measures can be divided into two types: mutual insurance and self-insurance [Hayashi (1996)]. Mutual insurance provides consumption smoothing opportunities across households through market or non-market mechanisms [Mace (1991)]. First, formal insurance markets act as effective consumption insurance by nature. Second, households can utilize credit market transactions, i.e., rely on borrowing, to smooth consumption by reallocating future resources to current consumption.[3] Third, a household can achieve consumption smoothing through informal arrangements of state-contingent mutual transfers among relatives, friends, and neighbors [Cochrane (1991); Hayashi et al. (1996); Mace (1991); Townsend (1987, 1994)].[4] Finally, governments can also complement the risk-coping behavior of households. Direct public transfers through means-tested targeting, tagging, or geographical/group targeting such as unemployment insurance or workfare can act as a formal safety net for households facing difficulties.

Self-insurance can be attained by dissaving. In the event of unexpected negative shocks, households can utilize their own financial and physical assets that have been accumulated beforehand [Carroll and Kimball (2006); Lee and Sawada (2007)]. Such precautionary savings can be in the form of bank deposits, cash holdings, jewelry, or physical assets like real estate. Skidmore (2001) has attributed the high savings rate of the Japanese to the high frequency of catastrophes such as earthquakes, volcanic eruptions, landslides, and typhoons.

[3] It can be shown theoretically that a lack of consumption insurance is compensated for by easy access to the credit market [Eswaran and Kotwal (1989)]. However, households often have limited access to credit markets, which can be attributed to high information costs and/or lack of assets for collateral. The existence of credit constraints has a significant negative impact on households' asset portfolio choice and risk-coping abilities [Paxson (1990); Lee and Sawada (2007)].

[4] It is also important to note that the self-enforcement mechanisms of this self-interested mutual insurance scheme could be sustained as sub-game perfect Nash equilibria in a repeated game framework [Coate and Ravallion (1993); Kocherlakota (1996)].

In what follows, we present a model of full consumption insurance incorporating non-separability across different expenditure items. We then formulate a simple theoretical and empirical framework to examine the effectiveness of risk-coping measures employed for mutual and self-insurance to deal with unexpected damages caused by natural disasters.

2.1 Full Consumption Risk-Sharing

First, we formulate full consumption insurance model in a pure exchange economy to characterize the role of mutual insurance [Cochrane (1991); Mace (1991); Townsend (1987)]. We aim to test the efficacy of informal/formal networks and/or markets to achieve efficient resource allocation. Let us assume that households trade dated claims contingent upon a sequence of states at time t, $s^t = [s_0, s_1, \cdots, s_t]$, where s_t refers to publicly observable states at time t. All of these claims are traded at time zero and there exists a complete set of securities for these contingent claims that are traded at the state-contingent price, i.e., households purchase a history-dependent consumption plan. Then the optimization problem of household *i,* deriving concave instantaneous utility from consumption of multiple goods, c^m, can be represented as intertemporal utility maximization subject to a lifetime budget constraint given contingent market prices. Such an optimization problem can be solved as the Pareto-optimal consumption allocation of a hypothetical social planner. The problem corresponds to Negishi's (1960) weighted utility maximization subject to the economy's goods market equilibrium condition [Mace (1991)]:

$$\max \sum_{i=1}^{N} \lambda^i \left\{ \sum_{t=1}^{\infty} \sum_{s^t \in \Omega^t} \left(\frac{1}{1+\delta} \right)^t \pi^i (s^t) u\left[c_{it}^1 (s^t), c_{it}^2 (s^t), \cdots, c_{it}^M (s^t) \right] \right\}$$
$$s.t. \sum_{i=1}^{N} c_{it}^m (s^t) \leq \sum_{i=1}^{N} \omega_{it}^m (s^t), \forall s^t \text{and } m = 1,2,\cdots,M, \qquad (1)$$

where λ^i is the weight for the ith household, π is the probability attached to a particular history of states, ω represents the household's stochastic endowment of each good that is exogenously given and depends on the realization of s_t, and Ω^t represents a set of the entire history of all possible states at time t. We impose a common-knowledge assumption that there exists an objective probability, π (s^t), for the occurrence of s^t. We also assume the same time discount rate δ across households. From the first order conditions of this problem, we have an optimal condition for the intertemporal allocation of consumption for the jth and ith consumer:

$$\left(\frac{1}{1+\delta} \right)^t \lambda^i \cdot \pi(s^t) \frac{\partial u}{\partial c_{it}^m} = \mu_t^m, \forall s^t \text{ and } m \qquad (2)$$

where μ^m denotes the Lagrange multiplier associated with the feasibility constraint of each good. This equation indicates that the hypothetical social planner will allocate endowments so as to equalize households' weighted marginal utility across household. It should be noted that μ^m is a negative function of initial income and assets. From equation (2), we have:

$$\frac{\partial u / \partial c_{it}^m}{\partial u / \partial c_{it-1}^m} = \frac{\partial u / \partial c_{jt}^m}{\partial u / \partial c_{jt-1}^m}, \qquad (3)$$

Equation (3) shows that, under the full consumption insurance hypothesis, households' allocation of consumption should be independent of idiosyncratic endowment changes.

2.1 Non-separable utility function

Most existing studies on full insurance further impose the assumption of a single good or separable multiple goods to secure sufficient tractability. However, the validity of the separability assumption has been rarely examined; an exception is a paper by Attanasio and Weber (1995). In order to bridge the gap in previous studies, we assume that the utility function is time- and state-separable but non-separable across goods. We follow Mace (1991) to postulate exponential utility:

$$u\left[c_{it}^{1}\left(s^{t}\right), c_{it}^{2}\left(s^{t}\right), \cdots, c_{it}^{M}\left(s^{t}\right)\right] = \frac{1}{\alpha}\left\{\sum_{m=1}^{M}\theta_{m}[-\exp(-\sigma(c_{it}^{m} - a_{it}^{m}))]\right\}^{\frac{\alpha}{\sigma}} - \frac{1}{\alpha} \qquad (4)$$

where a^{m} is a goods specific taste shock. Considering the case of two goods, i.e., m=1 and 2, we follow Mace (1991) to show that equations (3) and (4) yield:

$$\Delta c_{it}^{1} = \Delta\left(\frac{1}{N}\sum_{i=1}^{N} c_{it}^{1}\right) + u_{it}^{1}. \qquad (5)$$

$$\Delta c_{it}^{2} = \Delta\left(\frac{1}{N}\sum_{i=1}^{N} c_{it}^{2}\right) + u_{it}^{2}. \qquad (6)$$

where Δ is a first-difference operator and

$$u_{it}^{m} \equiv \Delta a_{it}^{m} - \Delta\left(\frac{1}{N}\sum_{i=1}^{N} a_{it}^{m}\right) + \xi_{it} \,. \tag{7}$$

Hence, we obtain $cov(u^1, u^2) \neq 0$ under non-separability. When utility is separable (σ=α), we obtain ξ=0, indicating that $cov(u^1, u^2)=0$ [Mace (1991)]. Equations (5) and (6) indicate that, under full insurance, idiosyncratic household income changes should be absorbed by all other members in the same insurance network. As a result, idiosyncratic income shocks should not affect consumption changes.

Taking the weighted average of equations (5) and (6) with the consumption share as the weight, we can obtain the equation of aggregated consumption for household *i* at time *t*, which is usually employed to test whether the full consumption risk sharing hypothesis holds.

$$\Delta c_{it} = \Delta\left(\frac{1}{N}\sum_{i=1}^{N} c_{it}\right) + u_{it} \,. \tag{8}$$

2.3 Risk-coping strategies

Next, we turn to the theoretical discussion of the determinants of households' risk-coping strategy. Even in the absence of full consumption risk sharing for contingent claims, households are able to insure themselves against unexpected shocks. We follow Fafchamps and Lund's (2003) model of risk coping behavior under perfect or imperfect risk sharing model. From the individual intertemporal budget constraint, we have $y_t^T + y_t^N - n_t = s_t + c_t$, where y_t^T, y_t^N, n_t, and s_t are transfer income, non-transfer income, a negative shock to household assets, and net savings, respectively [Fafchamps and Lund (2003)]. We assume that transfer income is determined endogenously, while non-transfer income and asset shocks are exogenously given. Following Fafchamps and Lund (2003), combining the intertemporal budget constraint mentioned above with equation (8) gives:

$$\Delta b_{it} + \Delta y_{it}^{T} + \Delta d_{it} = -\Delta y_{it}^{N} + \Delta n_{it} + \Delta\left(\frac{1}{N}\sum_{i=1}^{N} c_{it}\right) + e_{it}\,, \tag{9}$$

where b and d are borrowing and dissaving, respectively. The last term on the right-hand side represents the mean zero independent expectation error. Equation (8) formally shows that there are three possible risk-coping strategies against realized negative shocks: additional borrowing, receiving transfer income, or dissaving.

3. The Data Set and Summary Statistics

We take advantage of a rich household-level dataset from the *Shinsai-go no Kurashi no Henka kara Mita Shohi Kozo ni Tsuite no Chosa Hokokusho* (Research Report on Post-Disaster Changes in Lifestyles and Consumption Behavior). The survey was conducted by the Hyogo Prefectural government in October 1996, twenty months after the disaster, in the five areas seriously damaged by the earthquake: Kobe's Higashinada, Kita, and Suma wards, Akashi City, and Nishinomiya City [Hyogo Prefecture (1997)].[5] The survey was completed by 1,589 women aged above 30, who were selected on the basis of a stratified random sampling scheme. For more information, see Sawada and Shimizutani (2005; 2007b).

[5] The dataset was released on March 25, 1997, by *Hyogo-ken Seikatsu Bunka-bu Seikatsu Sozo-ka Shohi Seikatsu Taisaku-shitsu* (Hyogo Prefecture, Department of Livelihood and Culture, Livelihood Creation Section, Office for Livelihood Policy).

Definitions and summary statistics of variables are given in Table 1. First, we observe a variety of shocks caused by the earthquake.[6] About 30 percent of households in the sample experienced major or moderate damage to their housing and an additional 40 percent of households suffered minor damage. In total, about 70 percent of households in the sample suffered damage to their housing. Moreover, 70 percent of the sample households suffered major damage to household assets while an additional 20 percent experienced minor damage to household asset. In other words, more than 90 percent of respondents experienced some sort of damage to household assets. As to the income changes before and after the earthquake, 6 % and 34% of all respondents faced positive and negative income shocks, respectively, caused by the earthquake. About 60% of respondents reported that there was no income change. These figures demonstrate the seriousness of the economic loss caused by the earthquake. At the same time, the disaster caused a variety of exogenous shocks to residents in the Kobe area and allows us to perform a powerful test to identify the effect of the shocks on households' behavior.

Second, we find that more than 60 percent of respondents answered that their household's overall consumption changed after the earthquake. Although our data do not allow us to identify whether consumption increased or decreased, what is clear is that a large proportion of victims altered their consumption behavior after the event. The survey also provides ten different expenditure categories and asked respondents with regard to which item their consumption changed. We observe a large variation across expenditure items. About 30 percent of households changed their expenditure on furniture reflecting the large proportion of residents who suffered damage to household assets. Moreover, a quarter of households altered

[6] First, the survey was carried out in order to record the details of the damage respondents suffered as a result of the earthquake, such as damage to their housing, to household assets, and to the health of family members. It should be noted that, shortly after the earthquake, local governments conducted metrical surveys and issued formal certificates for housing damage, with which households could later obtain government compensation. Therefore, we believe that the information obtained on housing damage is fairly objective and accurate.

their expenditure on clothing and more than 20 percent changed their expenditure on daily goods. In contrast, less than 10 percent of households changed their expenditure on luxuries, leisure, or gifts. We will examine which type of shocks caused changes in consumption behavior for each category below.

Next, the survey asked respondents if they had experienced an increase in expenditure due to the earthquake, and if so, how they had coped with the increase. More than 80 percent replied that their expenditure had increased as a result. However, some households did not disclose how they coped with the extra expenditure caused by the earthquake. Consequently, our analysis concentrates on households that experienced a change in expenditure and provided information on their coping strategy, while households that did not change their expenditure or that changed their expenditure but did not indicate their coping mechanism are excluded from our sample for the risk-coping analysis. Among the households that increased their expenditure due to the earthquake, approximately 25 percent managed to cope by changing the composition of consumption and more than half relied on their savings. Borrowing and receiving transfers represented important risk-coping strategies for approximately 10 percent and 12 percent of valid responses, respectively. When estimating various risk-coping models, we employ binary dependent variables for the three risk-coping strategies, i.e., borrowing, receiving private/public transfers,,and dissaving.[7]

Turning to household characteristics, the rate of house ownership was approximately 70

[7] The questionnaire inquired about both the most important strategy (single choice) and other strategies (multiple choices). The estimation described in this study only utilizes the single-choice answers. Borrowing includes borrowing from financial institutions, relatives, and/or friends. Dissaving includes the drawing down of savings for retirement, for children (e.g., education costs), housing expenditure (purchases or renovation), the purchase of durables (e.g., automobiles), spending on leisure (personal trips), and preparing for unexpected events (disasters or sickness). Ideally we could have divided transfers into private and public ones. Yet, the small shares of private and public transfers did not allow the multivariate probit estimation to converge.

percent prior to the earthquake and approximately 30 percent of all households had outstanding housing loans. The average age of respondents was 51 years and the level of educational attainment of the majority of respondents was high school graduate or lower. A majority of respondents lived with their children, while approximately 20 percent lived with their parents or grandchildren. In terms of marital status, 5 percent of the surveyed respondents were single.[8] Finally, in order to control for average consumption changes in equations (5), (6), and (9) and unobserved heterogeneity which may result from differences in the impact of the earthquake, we include district-specific dummy variables. Since, among other things, the average effects of the earthquake are determined by the proximity to its hypocenter, we believe that the inclusion of the district dummies is reasonable.

4. Testing the Full Consumption Insurance Model

First, we test the full consumption insurance model of equations (5) and (6). Following Cochrane (1991) and Ravallion and Chaudhuri (1997), an estimation equation based on equations (5) and (6) can be expressed as follows:

$$\Delta c_i^m = \sum_{k=1}^{K} \delta_k R_k^a + S_i \gamma + X_i \beta + u_i^m , \qquad (10)$$

where k is an identifier of regional insurance networks and R^a is a dummy variable, which is equal to one if the ith household is located in the region, k. We use the area dummies for the

[8] Also, household income at the time of the survey was recorded by income category. Median annual household income was between ¥6 million and 8 million (approximately US$50,000-67,000).

variable R^a to control for consumption averages in equations (6) and (7). The matrix S comprises indicators of the damage to housing and household assets, while the matrix X consists of household characteristics to control for the observed part of household taste shocks. The final term on the right-hand side of the equation is a well-behaved error term. The null hypothesis of a full consumption insurance market is that all the elements of the vector γ in equation (10) are jointly zero.

Unfortunately, we do not have data on expenditure amounts. However, qualitative information on changes in the expenditure on the following ten consumption categories is available: food, daily goods, clothing, luxuries, leisure, gifts, furniture, electronic products, housing, and emergency supplies. We construct an indicator variable, I^c, which takes a value of one if a household changed its expenditure on item m and zero if no change in consumption is observed:

$$I_i^m = 1\left[\sum_{k=1}^{K} \tilde{\delta}_k R_k^a + S_i \tilde{\gamma} + X_i \tilde{\beta} + \tilde{u}_i^m > 0\right] \tag{11}$$

where m refers to each item of goods (m=1,2, …, 10). As discussed in Section 2, it is natural to assume that households' preferences with regard to multiple goods are not additively separable in the face of an unusual disaster shock and we consider the joint-determination of expenditure on each item. Under the assumption of joint normality of the error terms, our model is a ten-equation multivariate probit model to take into account the fact that household expenditure is determined by a simultaneous decision-making process. If the utility function is separable, error terms should be uncorrelated across consumption items, but if utility is not separable across goods, the error term in each equation is correlated with those in the other equations. For identification, we need to impose the conditions that var($\tilde{u}_i^m$) = 1 for all m and that the variance-covariance matrix of $\tilde{u}_i^m$ is symmetric. In order to estimate the parameters under this setting, we can employ the log-likelihood function, which depends on the joint standard normal distribution function. We utilize the algorithm given in Cappellari and Jenkins (2003) in order to estimate the multivariate probit model using the method of simulated maximum likelihood, also known as the Geweke-Hajivassiliou-Keane (GHK) estimator.

Table 2 reports the estimation results for the full-insurance model when households' preferences are not separable across multiple goods. We find that the full consumption insurance model is rejected except for the case of gift expenditure. When we look at each item closely, we find that the expenditure on furniture and on housing is proportional to the disaster damage to housing, but in the case of other items, most of the coefficients on housing damage are not statistically significant. Households which suffered damage to their household assets were more likely to change their expenditure on daily goods, clothing, furniture, electronic products, and emergency supplies. It is interesting to note that changes in expenditure on five out of ten items are correlated with the variable indicating that the health of a family member was affected by the earthquake, implying that health shocks substantially alter consumption behavior. Finally, although we do not report the covariances for each pair of error terms, all covariances are positive and statistically significant at the 1 percent level, indicating that our assumption of non-separability across goods is justified.

In summary, our analysis produces two main findings. First, we conclude that formal and informal mutual insurance mechanisms to deal with the impact of the earthquake were incomplete and, as a result, people in the affected area did not succeed in smoothing their consumption. This finding indicates that households were not able to efficiently cope with the damage and were forced to change their expenditure patterns. Second, we find supportive evidence that households' preferences were not separable across multiple goods and that the various types of damage sustained cause a substantial variation in expenditure on each category. This means that the implicit assumption of separability, which is frequently employed in most previous studies on full consumption risk sharing, should be examined carefully in future studies.

5. The Determinants of Risk-coping Strategies

The full consumption insurance model is rejected in the case of the Kobe earthquake. However, a test of full consumption risk-sharing provides little information on the way risks are shared among people. Thus, in order to examine these issues, we apply the empirical model of Fafchamps and Lund (2003) and investigate households' risk coping behavior against damages caused by the earthquake. Since the adoption of a particular risk-coping strategy is observed as a discrete variable in our data, we jointly estimate three binary-dependent variable models based on the different risk-coping strategies. Based on equation (9), we assume that the three different risk-coping strategies are dependent on each other through the correlations of error terms, ε_m, m=1, 2, 3 and 4.

$$\Delta b_i = Y_i\boldsymbol{\theta}_1^{\mathbf{Y}} + S_i\boldsymbol{\theta}_1^{\mathbf{S}} + X_i\boldsymbol{\beta}_1 + \varepsilon_{1i}, \quad (12)$$

$$\Delta y^T{}_i = Y_i\boldsymbol{\theta}_2^{\mathbf{Y}} + S_i\boldsymbol{\theta}_2^{\mathbf{S}} + X_i\boldsymbol{\beta}_2 + \varepsilon_{2i}, \quad (13)$$

$$\Delta d_i = Y_i\boldsymbol{\theta}_3^{\mathbf{Y}} + S_i\boldsymbol{\theta}_3^{\mathbf{S}} + X_i\boldsymbol{\beta}_3 + \varepsilon_{3i}, \quad (14)$$

$$p_{1i} = 1[\Delta b_i > 0], \quad (15)$$

$$p_{2i} = 1[\Delta y^{ET}{}_i > 0], \quad (16)$$

$$p_{4i} = 1[\Delta d_i > 0], \quad (17)$$

where Y represents household income changes. We do not directly observe the intensities of the risk-coping strategy, i.e., Δb, Δy^T, and Δd; rather, whether a particular risk-coping strategy is adopted is observed as a discrete variable. Hence, our dependent variables express whether a household adopted a particular risk-coping device, which can be represented by three indicator variables, p_m, $m = 1$, 2 and 3. We assume that the variance-covariance matrix of ε_{mi} is symmetric and the covariances are not necessarily zero. We need to impose the condition $\text{var}(\varepsilon_{1i}) = \text{var}(\varepsilon_{2i}) = \text{var}(\varepsilon_{3i}) = 1$ for identification. Under the assumption of joint normality of the error terms, our model is a three-equation multivariate (trivariate) probit model. Similar to the estimation in the previous section, we employ the algorithm given in Cappellari and Jenkins (2003) to obtain the Geweke-Hajivassiliou-Keane (GHK) estimator.

Table 3 reports the results, which can be summarized as follows. First, the negative income shock variable has positive coefficient for the borrowing equation, indicating that borrowing is effective against negative income shock. The positive income change variable affect transfers positively. This may suggest that more transfers are provided if income becomes larger, which may be seen as a case of the self-interested exchanges in Cox (1987). Yet, these income change coefficients are largely insignificant. Since equation (9) indicates that the full consumption risk-sharing hypothesis is consistent with a significant coefficient on income changes, these results are not necessarily supportive to the full risk sharing hypothesis.

Second, the column for borrowing reveals that people primarily coped with major or minor housing damages by borrowing. Additionally, we observe that borrowing was possible particularly for those who owned houses prior to the earthquake, which highlights the importance of collateral in obtaining a loan after the earthquake [Sawada and Shimizutani (2007b)]. Alternatively, credit-constrained households might have been unable to utilize borrowing as a risk-coping device against the negative shocks caused by the earthquake. The marginally significant and positive coefficient on the dummy indicating whether a respondent lived with parents or grandchildren is consistent with anecdotal evidence that the constructions of *nisetai jutaku* (two-generation houses) by using housing loans gained great popularity among households who lost their house because of the earthquake, since households with multiple generations find it easier to borrow and thus construct new houses.

The column for transfers in Table 3 shows the results for the determinants of aggregate transfers from private and public sources. While the results are less evident than those on borrowing, we find that the coefficient on the moderate housing damage is statistically significant, suggesting that, with transfers, households weathered such damage. That receiving transfers is correlated with the size of the damages is partly explained by the fact that the public committee in charge of allocating people's contributions distributed larger amounts of money to households with greater damage to their houses. In contrast to borrowing, the coefficient on the dummy variable indicating whether a respondent lived with parents or grandchildren is negative and significant, implying that those households are less likely to depend on transfers. This is natural since family members of those types of households are more likely to suffer from the same disaster and are less affordable than those households whose family members live separately and are more likely to be insured from damages caused by the earthquake. Moreover, most coefficients on the area dummies are significantly negative, implying that receiving transfers is affected by each region's indigenous character.

Third, the last column reports the results on the effectiveness of self-insurance. Since the coefficient on the dummy variable for minor household asset damage is positive and marginally significant, we may conclude that dissaving was employed as a risk-coping device in the case of minor damage to households' assets. Along with the finding that households relied on dissaving to compensate for smaller losses but coped with larger shocks by borrowing, our empirical findings suggest the existence of a hierarchy of risk-coping measures, starting from dissaving to borrowing. Moreover, those living with children were less likely to use dissaving as a coping strategy, as they probably had not accumulated sufficient precautionary savings.

Finally, the estimated correlations between the error terms in the case of the trivariate probit models are shown in Table 4. The correlations overwhelmingly reject the null hypothesis of independent error terms, a finding that supports the adoption of the trivariate probit model. More importantly, the covariances for the error terms of the borrowing and dissaving equations and of the transfer and dissaving equations are both negative. These findings imply that there exists a unobservable factor to account for negative correlation between dissaving and other risk coping devices and suggests that self-insurance acts as a compensation for the lack of mutual insurance. On the other hand, the covariance of the error terms of borrowing and transfers is positive, suggesting a complementary relation between borrowing and receiving transfers, though the coefficient is not significant.[9]

6. Concluding Remarks

In this study, we examined how people in the areas damaged by the Kobe earthquake in 1995 altered their expenditure and how they compensated for the losses sustained. We utilized

[9] The direction of the coefficient indicates that the rich, with collateralizable assets, can obtain both loans and transfer incomes, while the poor are excluded both from credit markets and from insurance networks against natural disasters.

a unique household-level dataset collected shortly after the earthquake. First, according to our estimation results, the full risk-sharing hypothesis is strongly rejected. Also, our results support a model that shows households' preferences are not separable across consumption items. Second, we then investigated the effectiveness of households' strategies to cope with losses caused by the earthquake since households were able to adopt a wide variety of risk-coping devices against the negative shocks created by the earthquake. We found that the means of coping were specific to the nature of the shock sustained as a result of the earthquake. Borrowing was extensively used to cope with housing damage, while dissaving was relied on to compensate for damage to smaller household assets. Additionally, we observed that dissaving and borrowing/transfers acted as substitutes. These findings suggest the existence of a hierarchy of risk-coping measures, starting from dissaving to borrowing.

Two policy implications can be drawn from these findings. First, the failure to smooth consumption after the disaster may have been mitigated by *ex ante* devices and it is imperative to design *ex ante* risk-management policies against earthquakes. The participation rate in earthquake insurance was very low before the earthquake. Without effective *ex ante* measures, the actual economic losses caused by an earthquake as enormous as the Great Hanshin-Awaji earthquake are too large for the government to support effectively. One example of *ex ante* mitigation is the further development of markets for earthquake insurance, which generate proper incentives to invest in mitigating the effect of earthquakes, such as investment in earthquake-proof construction. These *ex ante* measures would significantly reduce the overall social loss caused by an earthquake. Although our data set does not contain information on *ex ante* risk coping measures, future research should incorporate people's preventive behavior with regard to natural disasters.

Second, even though people in the affected areas failed to smooth consumption, employed a variety of coping measures depending on the size of the damage they suffered. We speculate that victims combined self- and mutual insurance schemes and did not heavily depend on government support, which explains the speed of the recovery. In the event of a natural disaster, the government may create a moral hazard problem by encouraging people to expose themselves to greater risks than required [Horwich (2000)]. After the earthquake, the central and local governments provided the largest financial support in the history of Japan for the reconstruction of the affected areas and to help the victims. However, because the number of those affected was so large, average direct transfers to victims were small. Our empirical results suggest that providing subsidized loans, rather than direct transfers, to victims may be a good example of facilitating risk-coping behavior; such interventions are less likely to create serious moral hazard problems. Although we do not deny that the government has to play a role in the face of natural disasters, policies to ensure that people take their own precautions are necessary for preparing well-designed social safety nets against future natural disasters.

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Table 1: Descriptive Statistics of the Variables Used

Description of Variables	Mean
Shock Variables	
Dummy = 1 if the earthquake caused major housing damage	0.129
Dummy = 1 if the earthquake caused moderate housing damage	0.175
Dummy = 1 if the earthquake caused minor housing damage	0.409
Dummy = 1 if the earthquake caused major household asset damage	0.079
Dummy = 1 if the earthquake caused minor household asset damage	0.707
Dummy = 1 if the earthquake adversely affected the health of a family member	0.213
Dummy = 1 for income did not change (default category)	0.593
Dummy = 1 for income increased	0.062
Dummy = 1 for income decreased	0.336
Dummy = 1 for income change information is missing	0.009
Expenditure shock	
Dummy = 1 if household consumption behavior changed after the earthquake	0.627
Dummy=1 if expenditure on food changed	0.188
Dummy=1 if expenditure on daily goods changed	0.215
Dummy=1 if expenditure on clothing changed	0.249
Dummy=1 if expenditure on luxury goods changed	0.056
Dummy=1 if expenditure on leisure goods and services changed	0.081
Dummy=1 if expenditure on gifts changed	0.073
Dummy=1 if expenditure on furniture changed	0.291
Dummy=1 if expenditure on electronic products changed	0.152
Dummy=1 if expenditure on housing changed	0.120
Dummy=1 if expenditure on emergency supplies changed	0.164
Coping Variables	
Dummy = 1 if the household faced an increase in expenditure due to the earthquake	0.803
Dummy = 1 if reallocation between expenditure items was the most important means of coping (default category)	0.250
Dummy = 1 if dissaving was the most important means of coping	0.537
Dummy = 1 if borrowing was the most important means of coping	0.096
Dummy = 1 if receiving transfers was the most important means of coping	0.117

Table 1: Descriptive Statistics of the Variables Used (continued)

Description of Variables	Mean (Standard Deviation)
Household Characteristics	
Dummy = 1 if the household owned a house prior to the earthquake	0.670
Dummy = 1 if the household had outstanding housing loans prior to the earthquake	0.316
Age of the respondent	51.168 (11.479)
Age squared	2749.872 (1202.06)
Dummy = 1 if the highest level of education of the respondent was high school	0.508
Dummy = 1 if the highest level of education of the respondent was junior college or equivalent	0.221
Dummy = 1 if the highest level of education of the respondent was university	0.135
Dummy = 1 if the respondent was single	0.049
Dummy = 1 if the respondent lived with children	0.614
Dummy = 1 if the respondent lived with parents or grandchildren	0.184
Regional Dummy Variables	
Dummy = 1 for Higashinada Ward (default category)	0.125
Dummy = 1 for Kita Ward	0.170
Dummy = 1 for Suma Ward	0.145
Dummy = 1 for Akashi City	0.334
Dummy = 1 for Nishinomiya City	0.210
Dummy = 1 for other areas	0.016

Note: Numbers in parentheses represent standard deviations.

Table 2: Tests of Full Consumption Risk-Sharing

Explanatory Variables	Food	Daily Goods	Clothing	Luxuries	Leisure
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
Dummy = 1 if major housing damage	-0.051	0.111	0.159	0.070	0.102
	(0.168)	(0.158)	(0.152)	(0.223)	(0.220)
Dummy = 1 if moderate housing damage	0.110	0.156	-0.148	0.077	0.345
	(0.133)	(0.129)	(0.128)	(0.186)	(0.175)**
Dummy = 1 if minor housing damage	-0.060	0.143	-0.117	-0.069	0.180
	(0.108)	(0.105)	(0.102)	(0.160)	(0.148)
Dummy = 1 if major household asset	0.267	0.520	0.415	0.063	0.278
damage	(0.201)	(0.190)***	(0.189)**	(0.281)	(0.239)
Dummy = 1 if minor household asset	0.205	0.248	0.325	0.215	-0.109
damage	(0.118) *	(0.116)**	(0.114)***	(0.180)	(0.149)
Dummy = 1 if adversely affected the	0.240	0.297	0.364	0.377	0.101
health of a family member	(0.106)**	(0.101)***	(0.099)***	(0.135)***	(0.133)
Dummy = 1 if owned a house prior to the	-0.238	-0.083	0.066	0.192	0.104
earthquake	(0.110)**	(0.105)	(0.103)	(0.151)	(0.137)
Dummy = 1 if had outstanding housing	0.136	0.044	0.014	-0.187	-0.038
loans prior to the earthquake	(0.108)	(0.102)	(0.100)	(0.152)	(0.134)
Age of the respondent	0.028	0.081	0.046	0.004	0.059
	(0.028)	(0.027)***	(0.027)*	(0.038)	(0.038)
Age squared	-0.0003	-0.0007	-0.0003	-0.00002	-0.0005
	(0.0003)	(0.0003)***	(0.0002)	(0.0004)	(0.0003)
Dummy = 1 if high school graduate	-0.090	-0.010	0.088	0.252	0.395
	(0.127)	(0.122)	(0.122)	(0.198)	(0.180)**
Dummy = 1 if junior college graduate or	-0.160	0.080	0.243	0.303	0.389
equivalent	(0.153)	(0.146)	(0.145)*	(0.229)	(0.209)*
Dummy = 1 if university graduate	-0.209	0.137	0.244	0.424	0.381
	(0.171)	(0.161)	(0.159)	(0.250)*	(0.232)
Dummy = 1 if single	0.138	-0.083	0.275	0.708	0.585
	(0.201)	(0.197)	(0.186)	(0.238)***	(0.222)***
Dummy = 1 if lived with children	-0.039	0.043	0.032	0.118	0.078
	(0.096)	(0.091)	(0.089)	(0.138)	(0.124)
Dummy = 1 if lived with parents or	0.029	0.140	0.231	0.052	0.044
grandchildren	(0.104)	(0.097)	(0.096)**	(0.143)	(0.129)
Dummy =1 if Kita Ward	0.165	0.087	-0.051	-0.106	0.031
	(0.155)	(0.153)	(0.149)	(0.236)	(0.220)
Dummy=1 if Suma Ward	-0.108	-0.095	-0.069	-0.064	0.123
	(0.156)	(0.153)	(0.146)	(0.221)	(0.204)
Dummy=1 if Akashi City	-0.130	0.067	-0.150	0.052	0.122
	(0.131)	(0.126)	(0.123)	(0.175)	(0.176)
Dummy=1 if Nishinomiya City	-0.192	0.003	-0.077	-0.128	0.159
	(0.150)	(0.144)	(0.140)	(0.213)	(0.198)
Dummy=1 if other areas	-0.660	0.043	0.499	0.221	0.616
	(0.385)*	(0.311)	(0.291)*	(0.382)	(0.334)*
Constant	-1.406	-3.451	-2.726	-2.447	-3.878
	(0.758)*	(0.746)***	(0.724)***	(1.060)**	(1.047)***

Note: The dependent variable was a dummy that took a value of one if household expenditure behavior with regard to each item changed after the earthquake and a value of zero otherwise. The Wald test is performed for the null hypothesis that the coefficients on shock variables are jointly zero (p-value). Coefficients rather than marginal effects are reported. Huber-White consistent robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 2: Tests of Full Consumption Risk-Sharing (continued)

Explanatory Variables	**Gifts**	**Furniture**	**Electronic Products**	**Housing**	**Emergency Supplies**
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
Dummy = 1 if major housing damage	-0.032	0.542	0.075	0.784	-0.171
	(0.201)	(0.150)***	(0.171)	(0.179)***	(0.180)
Dummy = 1 if moderate housing damage	-0.021	0.470	0.212	0.429	0.158
	(0.167)	(0.124)***	(0.136)	(0.158)***	(0.137)
Dummy = 1 if minor housing damage	-0.080	0.170	0.018	0.211	0.072
	(0.142)	(0.101)*	(0.112)	(0.134)	(0.110)
Dummy = 1 if major household asset damage	0.286	0.367	0.429	0.209	0.485
	(0.256)	(0.184)**	(0.205)**	(0.212)	(0.212)**
Dummy = 1 if minor household asset damage	0.250	0.314	0.277	0.0001	0.376
	(0.163)	(0.111)***	(0.124)**	(0.138)	(0.124)***
Dummy = 1 if adversely affected the health	0.146	0.114	0.264	0.097	0.118
of a family member	(0.128)	(0.099)	(0.105)**	(0.118)	(0.110)
Dummy = 1 if owned a house prior to the	0.109	-0.022	-0.038	-0.063	-0.070
earthquake	(0.139)	(0.101)	(0.114)	(0.124)	(0.113)
Dummy = 1 if had outstanding housing loans	0.048	0.226	0.156	0.030	0.029
prior to the earthquake	(0.133)	(0.097)**	(0.109)	(0.124)	(0.109)
Age of the respondent	0.009	0.070	0.018	-0.016	-0.022
	(0.035)	(0.026)***	(0.028)	(0.030)	(0.028)
Age squared	-0.0001	-0.0007	-0.0002	0.0001	0.0002
	(0.0003)	(0.0002)***	(0.0003)	(0.0003)	(0.0003)
Dummy = 1 if high school graduate	-0.184	0.329	0.176	0.258	-0.091
	(0.158)	(0.121)***	(0.137)	(0.157)*	(0.131)
Dummy = 1 if junior college graduate or	-0.125	0.284	0.265	0.220	0.077
equivalent	(0.189)	(0.145)**	(0.161)*	(0.184)	(0.154)
Dummy = 1 if university graduate	-0.143	0.227	0.202	0.386	0.220
	(0.209)	(0.158)	(0.176)	(0.199)*	(0.166)
Dummy = 1 if single	0.269	0.274	0.139	0.285	-0.229
	(0.235)	(0.182)	(0.211)	(0.222)	(0.233)
Dummy = 1 if lived with children	0.023	0.085	0.076	0.120	0.008
	(0.121)	(0.088)	(0.098)	(0.111)	(0.096)
Dummy = 1 if lived with parents or	0.164	-0.060	-0.043	0.021	0.090
grandchildren	(0.128)	(0.096)	(0.106)	(0.115)	(0.103)
Dummy =1 if Kita Ward	-0.534	-0.156	-0.079	-0.041	0.342
	(0.204)***	(0.147)	(0.158)	(0.189)	(0.160)**
Dummy=1 if Suma Ward	-0.252	-0.042	-0.224	-0.119	0.031
	(0.181)	(0.142)	(0.158)	(0.182)	(0.162)
Dummy=1 if Akashi City	-0.250	-0.079	-0.219	0.107	0.014
	(0.150)*	(0.120)	(0.130)*	(0.148)	(0.137)
Dummy=1 if Nishinomiya City	-0.558	-0.069	-0.106	0.058	0.045
	(0.188)***	(0.136)	(0.147)	(0.171)	(0.154)
Dummy=1 if other areas	-0.221	0.324	-0.021	0.281	0.048
	(0.366)	(0.282)	(0.313)	(0.313)	(0.336)
Constant	-1.540	-3.173	-1.950	-1.351	-0.845
	(0.944)*	(0.697)***	(0.765)**	(0.825)	(0.748)

Note: The dependent variable was a dummy that took a value of one if household expenditure behavior with regard to each item changed after the earthquake and a value of zero otherwise. The Wald test is performed for the null hypothesis that the coefficients on shock variables are jointly zero (p-value). Coefficients rather than marginal effects are reported. Huber-White consistent robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 3: Determinants of Different Risk-Coping Strategies

Explanatory Variables	Borrowing	Transfers	Dissaving
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
Dummy = 1 for income increased	0.184	0.692	-0.313
	(0.365)	(0.326)**	(0.298)
Dummy = 1 for income decreased	0.299	0.205	-0.037
	(0.174)*	(0.191)	(0.125)
Dummy = 1 for income change information is missing	0.929	-1.075	-1.069
	(0.788)	(59.853)	(0.854)
Dummy = 1 if the earthquake caused major housing damage	1.195	0.466	0.213
	(0.432)***	(0.327)	(0.245)
Dummy = 1 if the earthquake caused moderate housing damage	1.180	0.746	-0.062
	(0.394)***	(0.292)**	(0.204)
Dummy = 1 if the earthquake caused minor housing damage	0.803	0.016	0.023
	(0.370)**	(0.270)	(0.180)
Dummy = 1 if the earthquake caused major household asset damage	-0.473	-0.324	0.362
	(0.382)	(0.405)	(0.293)
Dummy = 1 if the earthquake caused minor household asset damage	-0.439	-0.379	0.334
	(0.246)*	(0.234)	(0.187)*
Dummy = 1 if adversely affected the health of a family member	-0.024	0.240	0.045
	(0.211)	(0.216)	(0.152)
Dummy = 1 if the household owned a house prior to the earthquake	0.425	-0.131	0.267
	(0.230)*	(0.245)	(0.160)
Dummy = 1 if the household had outstanding housing loans prior to the earthquake	-0.080	0.185	-0.237
	(0.207)	(0.216)	(0.152)
Age of the respondent	0.099	0.074	-0.046
	(0.069)	(0.078)	(0.047)
Age squared	-0.001	-0.001	0.001
	(0.001)	(0.001)	(0.000)
Dummy = 1 if the highest level of education of the respondent was high school	-0.396	0.092	-0.069
	(0.274)	(0.324)	(0.214)
Dummy = 1 if the highest level of education of the respondent was junior college or equivalent	-0.151	0.408	-0.140
	(0.304)	(0.353)	(0.242)
Dummy = 1 if the highest level of education of the respondent was university	-0.293	-0.006	-0.030
	(0.354)	(0.418)	(0.267)
Dummy = 1 if the respondent was single	0.520	0.198	-0.283
	(0.434)	(0.433)	(0.312)
Dummy = 1 if the respondent lived with children	0.273	-0.013	-0.251
	(0.201)	(0.188)	(0.140)*
Dummy = 1 if the respondent lived with parents or grandchildren	0.278	-0.469	-0.020
	(0.194)	(0.245)*	(0.152)
Dummy =1 if Kita Ward	-0.371	-0.838	-0.009
	(0.337)	(0.347)**	(0.224)
Dummy=1 if Suma Ward	-0.161	-0.476	0.256
	(0.300)	(0.297)	(0.222)
Dummy=1 if Akashi City	-0.128	-0.311	0.114
	(0.230)	(0.216)	(0.176)
Dummy=1 if Nishinomiya City	-0.029	-0.697	0.334
	(0.271)	(0.295)**	(0.211
Dummy=1 if other areas	-0.453	-0.605	0.159
	(0.735)	(1.038)	(0.479)
Constant	-4.347	-2.577	0.393
	(1.854)**	(2.067)	(1.243)
Sample size	522	522	522

Note: Coefficients rather than marginal effects are reported. Huber-White consistent robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 4
Covariances of Error Terms

	Covariance	Standard Error
Covariance between ε_1 and ε_2	0.110	(0.132)
Covariance between ε_1 and ε_3	-0.674	(0.069)***
Covariance between ε_2 and ε_3	-0.736	(0.068)***

Note: *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.