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Abstract

Using a unique household-level dataset pertaining to the situation of the 1995 Kobe earthquake, we address how households deal with extreme shocks. Our results show that changes in the expenditure of different consumption items before and after the disaster depend on the type of damage caused by the earthquake to each household in terms of income, housing, assets, and health. Moreover, we find that households' utility across different expenditure items is not separable. These results suggest the difficulties in carrying out in-kind transfers to the earthquake victims and the superiority of cash transfers when damages are easily verifiable. Moreover, risk-coping strategies depend on the damage: it was found that households borrowed extensively against housing damage but relied on dissaving to cope with smaller asset damage, implying that the risk-coping strategies are specific to the nature of the loss caused by the earthquake.

JEL codes: D12; D52; E21

Keywords: Natural disasters; Risk-coping strategies; Earthquake

1. Introduction

In a review article on the Kobe earthquake published in this journal, Horwich (2000) pointed out that events preceding and following an earthquake are seldom analyzed in terms of basic economic concepts.[1] This seems to be a serious omission in the relevant literature, because a number of natural disasters have taken place with increasing frequency in both developed and developing countries, and with climate change, this number is expected to increase (Khan 2005; EM-DAT 2007).[2] The purpose of this study is to fill this gap in the literature by addressing how households deal with extreme risks posed by natural disasters. For this purpose, in this study, we analyze households' responses to the Kobe earthquake by utilizing a unique household-level dataset collected from the Kobe area in Japan shortly after the devastating earthquake of 1995.

Along with other natural disasters, earthquakes surely result in extreme shocks that are exogenous, unexpected, and which often transmit a variety of risks to households. Moreover, in the case of the Kobe earthquake, there were no effective public compensations for the reconstruction of houses in spite of severe damages (Sawada and Shimizutani 2008, 2005); hence, this particular situation is ideal to examine households' pure responses to extreme events. Utilizing this natural experimental situation, we conduct two analyses: first, we explore whether the change brought about in different household expenditure items depends on the loss to income and damage to housing, assets, and health caused by the Kobe earthquake; second, using the framework developed by Fafchamps and Lund (2003), we investigate how the earthquake victims utilized risk-coping strategies to mitigate changes in consumption. While most of the previous studies have examined these issues separately, we adopt an integrated approach, examining both the consumption response to a variety of unexpected shocks and the factors determining what risk-coping strategies are adopted.

By conducting these analyses, we aim to quantitatively corroborate what Horwich (2000) pointed out: in spite of the tremendous damage, economic recovery in the Kobe area was much faster than initially expected. Lessons from the "successful recovery" in the wake of the Kobe earthquake may be crucial for designing appropriate policies to deal with future natural disasters in both developed and developing countries.

To preview our empirical results, our analyses show that the expenditures of most household consumption items are affected by the damage caused by the earthquake and that households' utility across different expenditure items is not separable. Our results indicate that when examining consumption response to a variety of shocks, it is inappropriate to impose the separability assumption that has commonly been imposed in most of the previous studies on the basis of the Panel Study of Income Dynamics (PSID) data (Blundell, Pistaferri, and Preston 2006). While we acknowledge the limitations of our dataset, we provide new evidence invalidating the separability assumption. Our result is consistent with that of Attanasio and Weber (1995), who show that the consideration of food consumption in isolation can yield misleading results.

Second, on conducting a comparative analysis on three different risk-coping strategies, namely, dissaving, borrowing, and transfers from private and public sources, we found that these strategies 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 are adopted particularly by multigeneration households.

By performing these analyses, we also aim to contribute to the debates on effective risk management policies against natural disasters. When the different types of damages are evident, it facilitates "targeted" in-kind transfers such as the provision of physical assets and houses. Our results, however, indicate that income, asset, housing, and health shocks affect different expenditure items simultaneously and that households' utility across different expenditure items is not separable. These results suggest difficulties in carrying out targeted in-kind transfers to the earthquake victims, because providing in-kind transfers to a targeted expenditure item will also change the marginal utility from other expenditure items. This interrelationship among different expenditure items complicates the procedure of fine-tuning the optimal mix of in-kind transfers. This is consistent with the emerging consensus among development policymakers on the suitability of cash and voucher transfers, rather than in-kind transfers, in complex emergencies arising from natural disasters (Harvey 2007). Alternatively, as discussed later, the government may organize transfers in more liquid forms or subsidized loan programs.

Although this study is not the first to examine the effects of the Kobe earthquake, we would like to emphasize that this study differs from the previous ones in two important respects. First, there has been no research examining the consumption responses to a variety of shocks that considers the nonseparability of goods in the context of natural disasters.[3] Second, we explicitly examine the relative effectiveness of various risk-coping strategies against unexpected natural disasters. As per our knowledge, only a few studies have employed household-level data to jointly and quantitatively investigate the role of savings, borrowing, and other risk-coping strategies (Rosenzweig 2001). However, an exception is a study by Fafchamps and Lund (2003), which investigated the joint determination of risk-coping strategies in the rural Philippines; we take a similar approach to examine households' choice of risk-coping strategies against natural disasters.

In another paper using the same dataset (Sawada and Shimizutani 2008), we separately examined the determinants of mutual insurance mechanisms through borrowing and private transfers, mainly focusing on the difference between borrowing-constrained and nonconstrained households. However, the paper does not address the joint determination of risk-coping strategies, nor does it consider self-insurance (dissaving), and thus, it did not allow us to examine the choice of risk-coping strategies under nonseparability in response to extreme shocks. Thus, we bridge this gap in the previous studies by employing a general model that takes into consideration both separable and nonseparable cases.

The remainder of this paper is organized as follows: Section 2 provides a brief overview of the dataset employed in this study; Section 3 examines whether consumption response depends on the damage incurred by each household; Section 4 presents the estimation results of the determinants of risk-coping strategies; and finally, Section 5 presents the concluding remarks.

2. Dataset 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 five areas that were seriously damaged by the earthquake: Kobe's Higashinada, Kita, and Suma wards; Akashi City; and Nishinomiya City (Hyogo Prefecture 1997).[4] The survey was completed by 1,589 women aged over 30, who were selected on the basis of a stratified random sampling method.

The definitions and summary statistics of the variables employed in this study are provided in Table 1. First, we observe a variety of shocks caused by the earthquake.[5] Approximately 70% of the sampled households suffered damage to their housing: approximately 30% suffered major or moderate damage, while approximately 40% suffered minor damage. Moreover, over 90% of the respondents experienced some sort of damage to household assets: approximately 70% of the sampled households suffered major damage, while approximately 20% suffered minor damage. In addition, approximately 20% of the respondents observed adverse effects on the health of a family member. With regard to the income changes before and after the earthquake, approximately 6% and 34% of all the respondents faced positive and negative income shocks, respectively, while approximately 60% of the respondents reported no income shock. These figures demonstrate the gravity of the economic loss caused by the earthquake.

Second, we summarize the household responses against these damages. We find that over 60% of the 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, it is clear that a large proportion of victims altered their consumption behavior after the event.[6] The survey also presented ten different expenditure items and asked the respondents with regard to which item their consumption changed. We observe a large variation across the expenditure items. Approximately 30% of the households brought about a change in their expenditure on furniture, reflecting the large proportion of residents whose household assets suffered damage. Moreover, approximately 25% of the households altered their expenditure on clothing and over 20% altered their expenditure on daily necessities. In contrast, less than 10% of the households altered their expenditure on luxuries, leisure, or gifts. We will later examine the types of shocks that brought about changes in the consumption behavior in each item.

Third, the survey asked respondents if they had experienced an unexpected, forced increase in expenditure due to the earthquake, and if so, how they had coped with such an increase. Over 80% of the respondents replied that they had experienced an increase in their expenditure.[7] Among the households that increased their expenditure because of the earthquake, approximately 25% managed to cope by altering the composition of their consumption and over 50% relied on their savings. Borrowing and receiving transfers constituted important risk-coping strategies for approximately 10% and 12% of valid responses, respectively.

Finally, with regard to household characteristics, the rate of house ownership was approximately 70% prior to the earthquake and approximately 30% of all households had outstanding housing loans. The average age of the respondents was 51 years, and the education level of a majority of the respondents was high school graduate or lower. A majority of the respondents lived with their children, while approximately 20% lived with their parents or grandchildren. With regard to marital status, 5% of the respondents were single.[8] Finally, in order to control for average consumption changes and unobserved heterogeneity, which may result from differences in the impact of the earthquake, we include district-specific dummy variables. Since, the average effects of the earthquake are determined by, among other things, the proximity to its hypocenter, we believe that the inclusion of the district dummies is reasonable.

3. Consumption Response to an Extreme Shock

First, we examine whether change in different expenditure items before and after the earthquake depends on the damage incurred by each household. We employ the following specification to address this issue:

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

where m refers to each item of goods (m = 1, 2,…, 10); k is an identifier of regional insurance networks; and R^a is a dummy variable that is equal to 1 if the ith household is located in the region k. We use the area dummies for the variable R^a to control for the consumption averages. The matrix S comprises the indicators of the loss to income and damage to housing, household assets, and health, while the matrix X consists of household characteristics to control for the observed household taste shocks. The final term on the right-hand side of the equation is a well-behaved error term.

Unfortunately, we do not have data on the expenditure amounts. However, qualitative information on changes in the expenditure on the following ten consumption items 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 the value of 1 if a change in a household's expenditure on item m is observed and the value of 0 if no change in consumption is observed.

$$I_i^m = 1\left[\sum_{k=1}^{K} \widetilde{\delta}_k R_k^a + S_i \widetilde{\gamma} + X_i \widetilde{\beta} + \widetilde{u}_i^m \neq 0 \right] \qquad (2)$$

As discussed in Section 2, it is natural to assume that the households' preferences with regard to multiple goods are not additively separable in the face of an unexpected disaster shock; hence, we consider the joint determination of expenditures on each item. Under the assumption of the joint normality of the error terms, our model is a ten-equation multivariate probit model that takes into account the fact that household expenditure is determined by a simultaneous decision-making process. As Sawada and Shimizutani (2007b) have shown by using the framework developed by Mace (1991), if the utility function is separable, error terms should be uncorrelated across consumption items, but if it 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, $\tilde{u}_i^m$, is symmetric. In order to estimate the parameters under this setting, we employ a 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, which is also known as the Geweke-Hajivassiliou-Keane (GHK) estimator.

Table 2 reports the estimation results. First, we observe that the negative income shock significantly affects the consumption behavior for all the items, except gift and emergency supplies; however, this is not the case for positive income shock. This implies that the income shock effect on consumption by items is asymmetric and also different from the pattern observed in the effect of damages to housing and household assets. Second, we find that all the expenditure items, except luxuries and gift, depend on the damage caused to housing and/or household assets of each household. On closely examining each item, we find that the expenditure on furniture and housing is proportional to the housing damage; however, in the case of other items, most of the coefficients on housing damage are not statistically significant. The households that suffered damage to their household assets were more likely to alter their expenditure on daily goods, clothing, furniture, electronic products, and emergency supplies. Third, it is interesting to note that changes in the expenditure on five out of ten items are correlated with the variable indicating that the earthquake adversely affected the health of a family member, thus implying that health shocks substantially alter consumption behavior. Finally, although we do not report the covariances for each pair of error terms, all the covariances are positive and statistically significant at the 1% level, indicating that our assumption of nonseparability across goods is supported empirically.

In summary, our analyses produce two main findings. First, we conclude that change in most of the expenditure items before and after the disaster depends on the damage incurred by each household. Specifically, we find that income declines affect most of the expenditure items, except gifts and emergency supplies; housing damages affect not only housing expenditure but also nonhousing expenditures such as leisure and furniture, and asset damages affect nonasset expenditures such as daily goods, clothing, and emergency supplies. These results suggest the difficulty in carrying out targeted in-kind transfers to the earthquake victims, because providing housing support to housing damages, for example, may also alter the expenditure of other items such as electronic products. Presumably, fine-tuning transfer amounts to achieve the optimal expenditure allocation pattern will not be easy. Second, we find corroborative evidence that households' preferences were not separable across multiple goods and that the various types of damage sustained caused a substantial variation in expenditure on each item. When the assumption of separability does not hold, the optimal consumption condition for the individual commodity depends on the consumption of other commodities as well; this also indicates the difficulty of using targeted in-kind transfers to compensate for specific losses suffered by expenditure items. In other words, these results suggest the superiority of transfers in more liquid forms, such as cash transfers. This may be considered as counterintuitive, because theoretical works such as Besley and Coate (1991) concluded that in-kind transfers can lead to a self-targeting mechanism that induce only the intended recipients to participate with the others opting out. In contrast, our results imply that cash transfers allow recipients to optimize what they should spend the money on under a situation of imperfect observability of household responses. We should also note that an earthquake creates observable and verifiable damages, and thus, screening problems analyzed by Besley and Coate (1991) seems to be less problematic. In practice, targeting cash support does not seem to be more problematic than targeting in-kind assistance (Harvey 2007).

4. Determinants of Risk-Coping Strategies

Next, we apply the empirical model of Fafchamps and Lund (2003) and investigate households' risk-coping strategies against damages caused by the Kobe 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 on the basis of different risk-coping strategies. On the basis of the correlations of error terms, we assume that the three different risk-coping strategies are interdependent.

$$\Delta b_i = S_i\boldsymbol{\theta}_1^{\boldsymbol{S}} + X_i\boldsymbol{\beta}_1 + \varepsilon_{1i}, \tag{3}$$

$$\Delta y^T{}_i = S_i\boldsymbol{\theta}_2^{\boldsymbol{S}} + X_i\boldsymbol{\beta}_2 + \varepsilon_{2i}, \tag{4}$$

$$\Delta d_i = S_i\boldsymbol{\theta}_3^{\boldsymbol{S}} + X_i\boldsymbol{\beta}_3 + \varepsilon_{3i}, \tag{5}$$

$$p_{1i} = 1[\Delta b_i > 0], \tag{6}$$

$$p_{2i} = 1[\Delta y^{ET}{}_i > 0], \tag{7}$$

$$p_{4i} = 1[\Delta d_i > 0]. \tag{8}$$

We do not directly observe the intensities of the risk-coping strategies, that is, Δb, Δy^T, and Δd; rather, whether a particular risk-coping strategy is adopted is observed as a discrete variable. Hence, our dependent variables indicate whether a household adopted a particular risk-coping strategy, which can be represented by three indicator variables: p_j, j = 1, 2, and 3. We assume that the variance-covariance matrix, ε_{ji}, is symmetric and the covariances are not necessarily 0. For identification, we need to impose the condition $\text{var}(\varepsilon_{1i}) = \text{var}(\varepsilon_{2i}) = \text{var}(\varepsilon_{3i}) = 1$. Under the assumption of the joint normality of the error terms, our model is a three-equation multivariate (trivariate) probit model. Similar to the estimation carried out in the previous section, we employ the algorithm given in Cappellari and Jenkins (2003) to obtain the GHK estimator.

Table 3 reports the results, which can be summarized as follows. First, the negative income shock variable has a positive coefficient for the borrowing equation, indicating that borrowing is effective against negative income shock. The positive income change variable positively affects transfers, possibly suggesting that more transfers are made if incomes increase; this may be considered as an example of the self-interested exchanges in Cox (1987). However, these income change coefficients are largely insignificant.

Second, the column for borrowing reveals that people primarily coped with major or minor housing damages by borrowing. In addition, we observe that borrowing was possible particularly for those who owned houses prior to the earthquake; this highlights the importance of land collaterals in obtaining a loan after the earthquake (Sawada and Shimizutani 2008).

Alternatively, credit-constrained households might have been unable to utilize borrowing as a risk-coping strategy 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 suggesting that using housing loans for the construction of *nisetai jutaku* (two-generation houses) gained immense popularity among the households that lost their houses to the earthquake, since households with multiple generations found it easier to borrow and fund the construction of 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 households weathered such damage with the help of transfers. The correlation between transfers and the extent of the damage is partly explained by the fact that the public committee in charge of disbursing funds expended larger amounts to households that suffered greater housing damage.[9] 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 the family members of such households are more likely to suffer from the same disaster and such households are less affordable than those where family members live separately and are more likely to be insured against damages caused by the earthquake. Moreover, most coefficients on the area dummies are significantly negative, implying that the transfers are 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 strategy only in the case of minor damage to households' assets. In addition to 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, from dissaving to borrowing. Moreover, those living with children were less likely to use dissaving as a risk-coping strategy, as they probably had not accumulated sufficient precautionary savings. These overall results on risk coping present a different picture from the subjective responses in Table 1, where more than half of the respondents reported that dissaving was the most important risk-coping strategy. This may suggest a potential problem in relying on subjective damage and risk-coping assessments of disaster victims.

Finally, the estimated correlations between the error terms in 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 both the borrowing and dissaving equations, and the transfer and dissaving equations, are negative. These findings imply that there exists an unobservable factor accounting for the negative correlation between dissaving and other risk-coping strategies, and they suggest 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 transfers, though the coefficient is not significant.[10]

5. Concluding Remarks

In this study, we examined how people in the areas damaged by the 1995 Kobe earthquake altered their expenditure and compensated for the losses sustained. We utilized a unique household-level dataset collected shortly after the earthquake. First, according to our estimation results, the changes in the expenditure before and after the earthquake depend on the damage incurred by each household; moreover, our results support a model that shows that households' preferences are not separable across consumption items. Second, we investigated the effectiveness of households' strategies to cope with losses caused by the earthquake, because we observed that households were able to adopt a wide variety of risk-coping strategies against the negative shocks caused by the earthquake. We found that the coping strategies were specific to the nature of the shock sustained: borrowing was extensively used to cope with housing damage, while dissaving was used for compensating smaller asset damages. These findings suggest the existence of a hierarchy of risk-coping measures, from dissaving to borrowing.

Two policy implications can be drawn from these findings. First, our empirical results show that the shock effects of the Kobe earthquake were diverse across households: while negative income shock altered consumption behavior in most of the items, asset shock affected certain items. In the case of the Kobe disaster, effective compensations for housing were not available in spite of huge damages incurred by households, but the recovery was relatively quick. This finding poses an important issue on the modality of disaster relief programs, that is, cash or in-kind transfers.

In the literature focusing on poverty, the exclusion and inclusion errors of means-tested targeting have been a serious concern under asymmetric information between government and transfer recipients (Besley and Coate 1992). An earthquake, however, generates tangible and verifiable damages, and thus, inclusion and exclusion errors in targeting policies seem to be less problematic. Moreover, our results indicate that income, asset, housing, and health shocks affect different expenditure items simultaneously and that households' utility across different expenditure items is not separable. These results suggest difficulties in carrying out targeted in-kind transfers to the earthquake victims, because providing in-kind transfers to a targeted expenditure will change the marginal utility from other expenditure items as well. This interrelationship among different expenditure items complicates the procedure of fine-tuning the optimal mix of in-kind transfers. Alternatively, the government may organize transfers in more liquid forms. Hence, our finding implies that cash transfers may be preferable when damages are easily identifiable and utility function is not separable across goods and services. This is consistent with the emerging consensus among development policymakers on the suitability of cash and voucher transfers, rather than in-kind transfers, in complex emergencies arising from natural disasters (Harvey 2007).

Second, the quick recovery process in Kobe can be attributed to self-insurance and mutual insurance through borrowing. After the earthquake, the central and local governments provided financial support—the largest in the history of Japan—for the reconstruction of the affected areas and the victims' welfare. However, because of the large number of victims, the average direct transfers to them were small. The earthquake victims apparently combined self-insurance and mutual insurance schemes effectively and did not depend heavily on government support, which explains the expeditious recovery. Our empirical results suggest that providing subsidized loans to victims may be effective in facilitating risk-coping behavior in the form of self-insurance. More importantly, such interventions are less likely to create serious moral hazard problems which are pointed by Horwich (2000). 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 necessary precautions independently and self-insurance are necessary for preparing well-designed social safety nets against future natural disasters.

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Table 1: Descriptive Statistics of the Variables

Description of Variables	Mean (Standard Deviation)
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	0.177
Dummy = 1 if income did not change (default category)	0.593
Dummy = 1 if income increased	0.062
Dummy = 1 if income decreased	0.336
Dummy = 1 if information on income change 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 experienced an increase in expenditure because of the earthquake	0.803
Dummy = 1 if adjustment between expenditure items was the most important coping strategy (default category)	0.250
Dummy = 1 if dissaving was the most important coping strategy	0.537
Dummy = 1 if borrowing was the most important coping strategy	0.096
Dummy = 1 if receiving transfers was the most important coping strategy	0.117

Table 1: Descriptive Statistics of the Variables (continued)

Description of Variables	Mean (Standard Deviation)
<u>Household Characteristics</u>	
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 respondent was a high school graduate	0.508
Dummy = 1 if the respondent was a junior college graduate or equivalent	0.221
Dummy = 1 if the respondent was a university graduate	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
<u>Regional Dummy Variables</u>	
Dummy = 1 if the respondent lived in Higashinada Ward (default category)	0.125
Dummy = 1 if the respondent lived in Kita Ward	0.170
Dummy = 1 if the respondent lived in Suma Ward	0.145
Dummy = 1 if the respondent lived in Akashi City	0.334
Dummy = 1 if the respondent lived in Nishinomiya City	0.210
Dummy = 1 if the respondent lived in any other area	0.016

Note: Numbers in parentheses represent standard deviations.

Table 2: Consumption Response to the Earthquake Shocks

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 income increased	0.068	–0.181	–0.119	–0.148	–0.356
	(0.177)	(0.178)	(0.173)	(0.278)	(0.290)
Dummy = 1 if income decreased	0.349	0.146	0.281	0.237	0.247
	(0.088)***	(0.084)*	(0.082)***	(0.121)*	(0.109)**
Dummy = 1 if information on income change is missing	0.076	0.240	–0.322	–2.749	–3.131
	(0.593)	(0.498)	(0.562)	(150.512)	(109.702)
Dummy = 1 if the earthquake caused major housing damage	–0.090	0.096	0.137	0.053	0.093
	(0.169)	(0.158)	(0.153)	(0.223)	(0.220)
Dummy = 1 if the earthquake caused moderate housing damage	0.090	0.145	–0.168	0.059	0.331
	(0.133)	(0.130)	(0.128)	(0.187)	(0.176)*
Dummy = 1 if the earthquake caused minor housing damage	–0.063	0.141	–0.117	–0.069	0.182
	(0.109)	(0.105)	(0.103)	(0.161)	(0.149)
Dummy = 1 if the earthquake caused major household asset damage	0.261	0.510	0.396	0.038	0.236
	(0.202)	(0.191)***	(0.189)**	(0.283)	(0.241)
Dummy = 1 if the earthquake caused minor household asset damage	0.213	0.246	0.315	0.208	–0.124
	(0.120) *	(0.117)**	(0.114)***	(0.182)	(0.150)
Dummy = 1 if the earthquake adversely affected the health of a family member	0.214	0.281	0.343	0.356	0.074
	(0.107)**	(0.101)***	(0.099)***	(0.137)***	(0.134)
Dummy = 1 if the household owned a house prior to the earthquake	–0.225	–0.077	0.080	0.202	0.111
	(0.111)**	(0.105)	(0.103)	(0.152)	(0.138)
Dummy = 1 if the household had outstanding housing loans prior to the earthquake	0.140	0.045	0.020	–0.178	–0.014
	(0.109)	(0.102)	(0.100)	(0.153)	(0.135)
Age of the respondent	0.019	0.075	0.038	–0.003	0.051
	(0.029)	(0.028)***	(0.027)	(0.038)	(0.038)
Age squared	–0.0002	–0.0006	–0.0002	0.00004	–0.0004
	(0.0003)	(0.0003)**	(0.0003)	(0.0004)	(0.0004)
Dummy = 1 if the respondent was a high school graduate	–0.052	–0.011	0.124	0.281	0.424
	(0.128)	(0.122)	(0.123)	(0.200)	(0.181)**
Dummy = 1 if the respondent was a junior college graduate or equivalent	–0.103	0.113	0.296	0.347	0.433
	(0.155)	(0.147)	(0.146)**	(0.232)	(0.211)**
Dummy = 1 if the respondent was a university graduate	–0.144	0.168	0.301	0.465	0.415
	(0.173)	(0.162)	(0.160)*	(0.254)*	(0.235)*
Dummy = 1 if the respondent was single	0.147	–0.087	0.277	0.706	0.576
	(0.201)	(0.197)	(0.186)	(0.239)***	(0.223)***
Dummy = 1 if the respondent lived with children	–0.027	0.052	0.042	0.126	0.088
	(0.096)	(0.091)	(0.089)	(0.138)	(0.125)
Dummy = 1 if the respondent lived with parents or grandchildren	–0.004	0.116	0.204	0.024	0.013
	(0.105)	(0.098)	(0.097)**	(0.145)	(0.132)
Dummy = 1 if the respondent lived in Kita Ward	0.148	0.062	–0.082	–0.138	–0.011
	(0.156)	(0.153)	(0.150)	(0.238)	(0.222)
Dummy = 1 if the respondent lived in Suma Ward	–0.126	–0.115	–0.091	–0.083	0.096
	(0.157)	(0.153)	(0.146)	(0.223)	(0.205)
Dummy = 1 if the respondent lived in Akashi City	–0.138	0.048	–0.170	0.033	0.091
	(0.132)	(0.126)	(0.124)	(0.176)	(0.177)
Dummy = 1 if the respondent lived in Nishinomiya City	–0.217	–0.027	–0.115	0.164	0.116
	(0.152)	(0.144)	(0.141)	(0.214)	(0.200)
Dummy = 1 if the respondent lived in any other area	–0.722	–0.008	0.437	0.155	0.532
	(0.388)*	(0.311)	(0.291)	(0.383)	(0.337)
Constant	–1.316	–3.324	–2.595	–2.326	–3.722
	(0.764)*	(0.750)***	(0.730)***	(1.067)**	(1.059)***

Note: The dependent variable is a dummy variable that takes the value of 1 if household expenditure on each item changed after the earthquake, and a value of 0 otherwise. The Wald test is performed for the null hypothesis that the coefficients on the shock variables are jointly 0 (p-value). Coefficients, rather than marginal effects, are reported. The Huber-White consistent, robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 2: Consumption Response to the Earthquake Shocks (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 income increased	0.089	0.040	–0.320	–0.270	–0.133
	(0.208)	(0.161)	(0.189)*	(0.218)	(0.177)
Dummy = 1 if income decreased	0.137	0.158	0.270	0.185	0.104
	(0.111)	(0.081)*	(0.088)***	(0.099)*	(0.090)
Dummy = 1 if information on income change is missing	–3.326	0.511	–3.26	0.238	0.086
	(120.691)	(0.485)	(85.359)	(0.602)	(0.608)
Dummy = 1 if the earthquake caused major housing damage	–0.042	0.524	0.057	0.771	–0.179
	(0.210)	(0.151)***	(0.172)	(0.180)***	(0.180)
Dummy = 1 if the earthquake caused moderate housing damage	–0.024	0.462	0.199	0.416	0.150
	(0.168)	(0.124)***	(0.137)	(0.159)***	(0.137)
Dummy = 1 if the earthquake caused minor housing damage	–0.073	0.168	0.028	0.213	0.071
	(0.143)	(0.102)*	(0.113)	(0.134)	(0.110)
Dummy = 1 if the earthquake caused major household asset damage	0.259	0.361	0.390	0.193	0.469
	(0.257)	(0.185)*	(0.206)*	(0.212)	(0.212)**
Dummy = 1 if the earthquake caused minor household asset damage	0.239	0.318	0.259	–0.0003	0.373
	(0.163)	(0.111)***	(0.125)**	(0.139)	(0.124)***
Dummy = 1 if the earthquake adversely affected the health of a family member	0.135	0.103	0.244	0.089	0.109
	(0.128)	(0.099)	(0.106)**	(0.118)	(0.110)
Dummy = 1 if the household owned a house prior to the earthquake	0.112	–0.021	–0.024	–0.050	–0.065
	(0.139)	(0.101)	(0.114)	(0.124)	(0.114)
Dummy = 1 if the household outstanding housing loans prior to the earthquake	0.048	0.226	0.169	0.030	0.030
	(0.134)	(0.097)**	(0.109)	(0.124)	(0.109)
Age of the respondent	0.004	0.065	0.007	–0.025	–0.027
	(0.035)	(0.026)**	(0.029)	(0.031)	(0.028)
Age squared	–0.00004	–0.0006	–0.0001	0.0001	0.0002
	(0.0003)	(0.0002)**	(0.0003)	(0.0003)	(0.0003)
Dummy = 1 if the respondent was a high school graduate	–0.165	0.345	0.209	0.280	–0.079
	(0.159)	(0.121)***	(0.137)	(0.158)*	(0.132)
Dummy = 1 if the respondent was a junior college graduate or equivalent	–0.105	0.313	0.316	0.259	0.099
	(0.190)	(0.145)**	(0.161)*	(0.185)	(0.155)
Dummy = 1 if the respondent was a university graduate	–0.114	0.259	0.235	0.413	0.238
	(0.211)	(0.159)	(0.177)	(0.201)**	(0.168)
Dummy = 1 if the respondent was a single	0.271	0.276	0.144	0.285	–0.232
	(0.235)	(0.181)	(0.213)	(0.223)	(0.233)
Dummy = 1 if the respondent lived with children	0.028	0.087	0.093	0.134	0.016
	(0.121)	(0.088)	(0.099)	(0.111)	(0.097)
Dummy = 1 if the respondent lived with parents or grandchildren	0.161	–0.078	–0.067	–0.008	0.074
	(0.129)	(0.096)	(0.107)	(0.116)	(0.104)
Dummy =1 if the respondent lived in Kita Ward	–0.541	–0.168	–0.130	–0.062	0.324
	(0.205)***	(0.147)	(0.159)	(0.190)	(0.161)**
Dummy = 1 if the respondent lived in Suma Ward	–0.245	–0.047	–0.254	–0.147	0.020
	(0.182)	(0.142)	(0.158)	(0.183)	(0.163)
Dummy = 1 if the respondent lived in Akashi City	–0.247	–0.086	–0.257	0.089	0.002
	(0.151)	(0.120)	(0.131)**	(0.148)	(0.137)
Dummy=1 if the respondent lived in Nishinomiya City	–0.569	–0.078	–0.155	0.027	0.026
	(0.189)***	(0.137)	(0.148)	(0.171)	(0.154)
Dummy=1 if the respondent lived in any other area	–0.233	0.294	–0.090	0.230	0.016
	(0.366)	(0.281)	(0.313)	(0.312)	(0.336)
Constant	–1.496	–3.088	–1.706	–1.147	–0.733
	(0.949)	(0.700)***	(0.768)**	(0.831)	(0.751)

Note: The dependent variable is a dummy variable that takes the value of 1 if household expenditure on each item changed after the earthquake, and a value of 0 otherwise. The Wald test is performed for the null hypothesis that the coefficients on shock variables are jointly 0 (p-value). Coefficients, rather than marginal effects, are reported. The 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 if income increased	0.184	0.692	–0.313
	(0.365)	(0.326)**	(0.298)
Dummy = 1 if income decreased	0.299	0.205	–0.037
	(0.174)*	(0.191)	(0.125)
Dummy = 1 if information on income change 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 the earthquake 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 respondent was a high school graduate	–0.396	0.092	–0.069
	(0.274)	(0.324)	(0.214)
Dummy = 1 if the respondent was a junior college graduate or equivalent	–0.151	0.408	–0.140
	(0.304)	(0.353)	(0.242)
Dummy = 1 if the respondent was a university graduate	–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 the respondent lived in Kita Ward	–0.371	–0.838	–0.009
	(0.337)	(0.347)**	(0.224)
Dummy=1 if the respondent lived in Suma Ward	–0.161	–0.476	0.256
	(0.300)	(0.297)	(0.222)
Dummy=1 if the respondent lived in Akashi City	–0.128	–0.311	0.114
	(0.230)	(0.216)	(0.176)
Dummy=1 if the respondent lived in Nishinomiya City	–0.029	–0.697	0.334
	(0.271)	(0.295)**	(0.211
Dummy=1 if the respondent lived in any other area	–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. The 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	Std. Err.
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.

1. 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 a natural disaster in history (Horwich 2000).

2. In the past few years alone, there have been several major disasters that resulted in tremendous human and economic losses; these include the Asian tsunami in 2004, Hurricane Katrina in 2005, and the earthquakes in Pakistan and Indonesia in 2005. Japan also has suffered severe natural disasters and probably is more at risk, especially from earthquakes, than many other countries.

3. Kohara, Ohtake, and Saito (2006) rejected the full consumption insurance hypothesis in the case of the Kobe earthquake, but they did not take into account the direct losses incurred by each household nor did they examine risk-coping strategies. Sawada and Shimizutani (2007a) used the same dataset as used in this study to examine the full insurance hypothesis by employing an ordered probit model; however, they did not consider nonseparability across multiple goods.

4. 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).

5. First, the survey was carried out in order to record the details of the damage incurred by the respondents due to the earthquake, such as damage to their housing, household assets, and health of family members. It should be noted that shortly after the earthquake, the 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.

6. We acknowledge the limitation of the dataset since households were not asked about whether there was an increase or decrease in the change; however, to our knowledge, this survey is the only source of information on expenditure on different items with a variety of unexpected shocks, which is indispensable for the test of nonseparability across goods.

7. Owing to the data availability constraints, the households that did not alter their expenditure or those that altered their expenditure but did not indicate their coping mechanism are excluded from our sample for the risk-coping analysis.

8. Moreover, the household income at the time of the survey was recorded by income category. The median annual household income was ¥6 million–¥8 million (approximately $50,000–$67,000).

9. However, the amount of publicly disbursed funds was negligible—¥100,000 (approximately $1,000) for the owner of each collapsed house.

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