How Is Consumption Smoothed against Income and Asset Shocks?

The Experience of an Earthquake in Yamakoshi Village*

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Abstract

We investigate how people insured themselves against unexpected losses caused by the Chuetsu earthquake in 2004. A novelty of our analysis is in the use of geological information as exogenous variations to identify the effects of the earthquake. While our empirical results show that our data is consistent with the conventional full consumption risk-sharing hypothesis for the entire village, liquidity constraints seem to inhibit the consumption risk sharing. Further examinations of each risk coping measures reveal that with all the employed measures, there are more than 22 percent of households whose net damage exceed 10 million yen or ninety thousand US dollars. These findings suggest a limitation of the standard test of full risk sharing using consumption data. The most important measure to cope with the earthquake risk was earthquake insurance, followed by donation and government transfer. On the other hand, private transfers play relatively and absolutely a small role. Finally, reductions in consumption and dissaving are measures employed only by well-off households.

Keywords: Natural disasters; Consumption risk sharing with self-consumption; Credit constraints; Risk-coping strategies

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1. Introduction

This paper aims to explore how a variety of markets and non-market arrangements are used as insurance mechanism against damages in a village, called *Yamakoshi*, that was hit by an outbreak of the Chuetsu earthquake in October 2004. Among different shocks to households, an earthquake is largely an unexpected, exogenous, and verifiable event, providing an unusually clean experiment to investigate the functioning of markets and non-market mechanisms. Specifically, we conduct three analyses. First, we examine the extent consumption is smoothed. Second, we investigate relative importance of a variety of insurance measures including self insurance, private and public transfers. Then, we estimate the average effect of damages on risk coping behavior and examine how households with different damages use different risk coping methods.

Figures 1(A) and (B) plot the percentage income changes and percentage consumption changes on the horizontal and vertical axes, respectively. Figure 1(A) reports the results for three income classes (below 5 million yen, between 5 to 8 million yen, and above 8 million yen) and Figure 1(B) for 14 blocks within Yamakoshi village. While we will conduct a formal analysis later, clearly consumption changes respond unsystematically to income changes. This finding is consistent with that by Blundell, Pistaferri and Preston (2006) and others. We aim to uncover the mechanism behind this smoothing.

In order to investigate how consumption is smoothed we examine consumers' reaction to an exogenous shocks to households varying over a wide range caused by a natural disaster. Our unique data set allows us to identify different measures to compensate economic losses. A household is able to self-insure by dissaving their assets as self-insurance and utilize mutual insurance through borrowing and receiving private and/or public transfers. Our survey enables us to investigate relative importance of each risk coping measures against economic losses of various sizes. By doing so, we will be able to uncover more closely the mechanisms behind the observed consumption smoothing.

Section 2 reviews some closely related literature. After a brief introduction of Yamakoshi village and the Chuetsu earthquake in Section 3, an overview of the data set and the relationship between a variety of income and asset shocks and changes in consumption are given. Section 4 performs a test of the consumption risk sharing model that is augmented by introducing credit constraints and discusses the empirical results. Section 5 investigates relative importance of different insurance measures including self-insurance, private transfers or co-residence, market mechanisms through insurance, credit and labor markets, and public transfer. Section 6 reports estimates of the average effect of damages on different risk coping devices. Particularly, how different households with different degree of damages combine the four routes of risk coping are examined. The final section presents concluding remarks.

2. Related Literature

In the last 15 years, there have been major developments in formulating and testing a full consumption insurance or complete market hypothesis using micro-data (Mace, 1991; Cochrane, 1991; Townsend, 1994; Attanasio and Davis, 1996; Hayashi, Altonji, and Kotlikoff, 1996; Ogaki and Zhang, 2004; Munshi and Rosenzweig, 2007; Blundell, Pistaferri, and Preston, 2008; Ligon, 2008).[1] The theoretical prediction of the full insurance model is that, under complete markets, idiosyncratic household income changes should be absorbed by all other members in the same insurance network. Accordingly, once aggregate shocks are controlled, idiosyncratic income shocks should not affect consumption when risk sharing is efficient. This implication of the complete markets has been tested in the existing studies using a wide variety of data set. Most results of these tests, however, reject the full consumption insurance, leading that researchers pursue models of partial risk sharing by incorporating various frictions in the risk sharing model (Ligon, 2008).

While such studies can investigate whether people might be able to cope with idiosyncratic risks efficiently, they are silent on the underlying mechanism behind completeness or incompleteness of the markets. There are only a few exceptions to explore how a household manages to deal with income shocks. Dynarski and Gruber (1997) utilize micro-level data from the US to quantify the degree of compensation of

[1] Kohara, Ohtake, and Saito (2006) has tested and rejected the full consumption insurance hypothesis against the Great Hanshin-Awaji earthquake by employing region-specific slope dummies for the income change variables.

taxes, spouse's labor supply and unemployment insurance in response to a household head's income changes. Fafchamps and Lund (2003) employed a unique panel data from the Philippines to show that risk is shared within networks of friends and relatives through flexible, zero interest informal loans combined with pure transfers. Hayashi, Altonji and Kotlikoff (1996) distinguish risk sharing within and between families to account for failure of the complete market models. More recently, Blundell, Pistaferri and Preston (2006) demonstrates that, as the effective mechanisms of full consumption insurance, taxes and transfers as well as family labor supply are found to play an important role in insuring permanent shocks.

These studies make significant contributions to the literature, uncovering the mechanisms behind the complete or incomplete markets. We further extend these studies and explore the mechanism of consumption insurances more directly. We believe that our data has three advantages over the existing ones, through which we can contribute to the existing literature on consumption insurance. First, most previous studies on consumption insurance examined consumption change in response to relatively small but more frequent income shocks, finding a smaller deviation from complete insurance. Yet, lacking a sufficient degree of exogenous variation, a high noise-to-signal ratio in measuring the shock variable may lead to serious attenuation bias in favor of the full risk sharing (Ravallion and Chaudhuri, 1997). In contrast, our shock measures of income changes and asset damages due to the earthquake have unusually large variations, enabling us to perform very powerful tests of consumption insurance.

Second, the information on the shocks to individual households in our data is accurate because the local government conducted metrical surveys to issue formal damage certificates. Also, earthquake damages to houses, farmlands, and offices are visible and easily verifiable. Hence, the assumption of perfect information is less problematic in our study. In contrary, the shock variables such as income changes in most of preceding studies are likely to be private information, rather than public knowledge, and thus the theoretical justification of complete information model is not necessarily warranted.[2]

[2] In fact, Ligon (1998) obtained supportive evidence of the imperfect information model against full consumption insurance model. Another issue is limited commitment (Ligon, Thomas, Worral, 2002; Munshi and Rosenzweig, 2007).

Finally, we carefully design the questionnaire and directly collected information on how people cope with the earthquake which are rarely available in the existing data sets. With this unique information, we can examine the reasons behind the acceptance or rejection of the full consumption risk sharing hypothesis explicitly and more accurately.

3. The Village and the Data Set

The village

Yamakoshi is a snowy village located in a mountainous area of Niigata prefecture, Japan (Figure 2). The estimated population slightly exceeded 2,100 people just before the disaster in the area of about 40 square kilometers. Yamakoshi was a typical rural village in Japan suffering from decline of younger population, a rapid speed of aging and heavy dependence on agriculture. While typical in that respect, the village was well known for its beautiful paddy rice terraces and also known as the world leading breeders of Japanese "Koi " carps.

In the evening of Saturday October 23, 2004, the Chuetsu earthquake struck the middle part of Niigata prefecture. The Richter scale of the disaster was 6.8 and the depth of the center was 13 km, not deep under the ground. The earthquake induced a human loss of 67, heavily injured 635 and injured more than 4,000 in Niigata prefecture (Niigata prefecture, 2006) . The housing property and capital stock losses were estimated to be more than 20 billion US dollars, making it one of the largest economic disasters in the new millennium (International Strategy for Disaster Reduction, 2005).

Yamakoshi village is closely located to the epicenter and thus was one of the most heavily hit areas by the earthquake. Accordingly, all the villagers were forced to leave out the village as we will see later. It is fair to say that people in Yamakoshi village did not expect a large earthquake and the event was completely unexpected. Figure 1 reports that Niigata prefecture belongs to the area whose earthquake insurance premium is at the third level out of four different regions to reflect on different risk of earthquakes. Since the most recent large landslides in the village took place in 1824 due to a thaw, the current villagers have never experienced such a disastrous catastrophe.

In Yamakoshi, five people died, 12 people were heavily injured and additional 13 people were injured (Niigata prefecture, 2006). In addition to the human losses, most of all the houses in the villages were damaged but the size of the losses was diverse; 285 collapsed houses, 56 half collapsed house, 234 houses with moderate damage and 106 houses with partial damages in the small village populated about 600 households. Moreover, resultant landslides forced closure of highways and smaller roads, making most localities in Yamakoshi isolated from outside. Since a continuous series of aftershocks increased the danger of further landslides, the government announced an evacuation order for the entire village families and all the villagers were evacuated successfully, two days after the earthquake. After two months of the onset of the earthquake, around 80% of all the villagers moved to temporal shelters provided by local governments, called "Kasetsu Jyutaku," in a neighboring city, Nagaoka.

The Survey

We design a household survey exclusively for this study. The survey was conducted in April and May 2006 with the residents of the former Yamakoshi village. The sample is the registered Yamakoshi households at the time of the disaster. With the strong cooperation of local governments with our intensive efforts to ask the residents to respond to our survey, the survey was completed by 597 households out of the total of 663 registered households in the village and the response rate was 90 percent, which is unusually high in Japan. Out of the respondents, 467 households lived in temporal shelters and the remaining 130 households were out of the shelters.

Our survey consists of four sections: (1) basic characteristics of the head of household and his/her spouse; (2) a wide variety of damages caused by the earthquake; (3) networks within communities or extended families; (4) changes of purchased consumption, proportion of purchased consumption, income, saving before and after the earthquake as well as risk copying measures employed to compensate the losses caused by the earthquake.

Damages to housing property, income shocks and consumption

Housing damages and reduction in income caused by the earthquake varies across blocks (Chiku) within Yamakoshi village. Figures 3(A) and (B) report the histograms for the housing damages and income changes across 14 blocks within Yamakoshi village. As reported in the last line of Table 1(A), more than a half of all houses were seriously destroyed (more than 40 percent of houses were completely collapsed and 10 percent was almost completely collapsed). In addition, 30 percent were classified as half-collapsed.

What we emphasize here is that the proportions of households with different damage sizes differ between and within the blocks. In several blocks with smaller population like Manaihira, Kajigane, Kigomo, Okubo, Iketani and Naranoki, more than 80 percent of the houses were totally destroyed. In contrast, some block with larger population like Tanesuhara, Mushigame and Takezawa had smaller proportion of totally collapsed houses and the shares of households with half-collapsed or minor damages are larger than those in other blocks.

Table 1(B) reports damages to workplaces and persons. The share of households with damages to their farms exceeded 70 percent but across blocks the rate varies. Damages to offices are more serious in the blocks with a higher portion of collapsed houses than others. This is not necessarily the case for damages to carp ponds because the proportion of villagers who owned a carp pond can be small in a block. In addition to 5 percent of households encountered a death of their members on or after the earthquake, 21 percent of the household suffered from other health problems caused by the disaster. Furthermore, we notice that, on average, about 40 percent of heads lost their jobs due to the earthquake and the share of those households varies from a quarter to 80 percent across blocks. This is confirmed in Table 2 also. The table reports the details of the income changes before and after the earthquake reported in Figure 2(B). First, we observe that about 40 percent of the households maintained their income unchanged while most of the remaining households experienced decline in income after the disaster. Second, we see a varying degree of income decreases across blocks, though less so than damages to houses. Some blocks which had a larger share of the unemployed due to the earthquake, like Kigomo and Okubo, also had larger share of households whose income decreased more than 50%.

The goal of this paper is to examine how a variety of shocks caused by a large, exogenous and unexpected natural disaster translates to people’s well being as measured by consumption.

Other characteristics

Table 3 reports the summary statistics of other household-level variables. First, the average age of the household head was 65. A majority of them were junior or senior high school graduates. About a half of the respondents were retired or unemployed and 28 percent, 15 percent, and 5 percent of the heads were salaried worker, farmer, and self-employed, respectively. The average numbers of sons and daughters is 1.2 persons, while a half of the sons and 60 percent of the daughters lived outside Yamakoshi village.

Second, prior to the earthquake, 95 percent of all the respondents owned detached houses. More than 87.1% of households owned farmland and the average sizes of residential lands and houses were 390 square meters and 144.9 square meters, respectively.

Third, we asked households about the important risk coping strategies against unexpected costs caused by the earthquake. The data enables us to identify directly the following five different types of risk coping strategies;

(1) Self-insurance (dissavings) which are decrements in savings originally accumulated for different purposes;
(2) Receipts of private transfers which contain gifts and credits from household members, relatives, and friends;
(3) Insurance indemnity payments which are entitled to receive from earthquake or other insurance companies;
(4) Receipts of public transfers consisting of two different sources; (a) publicly-provided special schemes for lending or subsidies applicable for the residents in the damaged areas and (b) people's donations to non-profit organizations whose allocation to the victims is centrally determined by a special public committee; and
(5) Credit (borrowing) from financial institutions and the local government.

Table 3 reports that approximately 70% managed to cope with the damages by dissavings, while only 4 percent utilized borrowing. Receiving insurance payments was also a significant risk coping strategy for approximately a half of the households. Moreover, private and public transfers were utilized by 52 percent and 74 percent of the respondents, respectively. As to the private transfers (excluding allocated donations through the public committee), the average amount of money and in-kind transfers received was about 0.85 million Yen (about 7,700 USD).

Fourth, before the earthquake, the proportion of self-consumption to total food consumption was about 45% on average. Then one of the key questions covered in the survey was whether a household's purchased consumption and self-consumption changed prior to and after the earthquake. The average growth rate of purchased food expenditure was 19 percent while that of self consumption declined by 65% due to the evacuation from the village. Hence, unlike the existing studies such as Cochrane (1991) which used food consumption from PSID data, our total food consumption variable which is a sum of purchased food consumption and imputed value of self-production, involve unexpected wide changes by nature. Hence, the use of food consumption data is less problematic in our data.

Finally, in order to identify the credit constrained households directly from the survey, the credit module of the survey includes a question, "before the earthquake, do you think you could borrow 10 million Yen (approximately 80,000 USD) from a bank to rebuild a house?" The answer choices for this question were: (a) Yes, I think so; (b) No, I do not think so; and (c) I do not know. We identify the respondents who chose from an option (a) of the lists as being unlikely to be credit-constrained with regard to formal sources. Yet, the remaining respondents were considered to be the constrained. According to our definition, more than 80 percent of households in Yamakoshi were likely to be credit-constrained.[3]

4. Testing the Augmented Consumption Risk Sharing Model

The model

In this section, we implement a new test of the complete risk sharing model to

[3] We asked the same question for "right after" and "five years after" the earthquake. We also tried a weaker constraint variable in which the respondents with an option (c) are treated as the non-constrained. The empirical results we will show later are similar qualitatively even if we use alternative classification method.

formally confirm the lack of a correlation between consumption changes and income or asset shocks. As the key features of our shocks, they are large, unusually rich in variety, completely unexpected, exogenous, and verifiable. These features have been seldom explored in the large literature on complete markets models (Mace, 1991; Cochrane, 1991; Townsend, 1994; Attanasio and Davis, 1996; Hayashi, Altonji, and Kotlikoff, 1996; Blundell, Pistaferri, and Preston, 2002; Ogaki and Zhang, 2004). The theoretical prediction of the full insurance model is that, once aggregate shocks are controlled, idiosyncratic income shocks should not affect consumption because idiosyncratic household income changes will be absorbed by all other members in the same insurance network. Under the complete market setting, we obtain the necessary conditions of the optimal resource allocation by solving a benevolent social planner's problem to maximize the weighted sum of people's utilities [Cochrane (1991); Mace (1991)]:

$$\frac{u_i'(c_{it-1})}{u_i'(c_{it})} = \frac{u_j'(c_{jt-1})}{u_j'(c_{jt})} = \frac{\lambda_{t-1}}{\lambda_t} \tag{1}$$

Where $u_i(\bullet)$ is a concave instantaneous utility of a household, *c* is the household consumption and *i, j* denotes *i, j* th household, respectively, and λ is a Lagrange multiplier associated with the total resource availability within a risk sharing network. Denoting the growth rate of consumption by g_{it}, since $c_{it} = c_{it-1}(1+g_{it})$, when the utility function is strictly concave, one can solve for $g_{it} = g_i(c_{it-1}, \lambda_{t-1}/\lambda_t)$.

Under full insurance, idiosyncratic household income changes and asset damages should be absorbed by all other members in the same insurance network and those shocks should not affect changes in consumption. Across households within the same risk sharing network, the distribution of consumption growth rate should differ only through the taste variation. Under the assumption that the taste and the income shocks induced by the earthquakes are independent, the growth rate distribution should be independent from the income shocks or asset damages given c_{it-1}.

Suppose that the utility function takes the form of a constant relative risk aversion function, i.e., $u(c_{it}) = [c_{it}^{1-\gamma}/(1-\gamma)] \exp(\theta_{it})$, where γ and θ are the coefficient of relative risk aversion and a household's taste shock, respectively. Then, from equation (1), we can show that $g_{it-1} = [(\log\lambda_{t-1} - \log\lambda_t) + (\theta_{it} - \theta_{it-1})]/\gamma$ and thus the same holds without conditioning on the past consumption. Accordingly, we examine the difference in consumption growth in response to different individual shocks by comparing the cumulative distribution functions (CDF) of consumption growth rate by different income and/or asset shocks.

Our test has two advantages over the existing ones. First, most of the previous studies examine the implication of the model in terms of mean whereas we examine the full distributional implication. In other words, a conventional test of full risk sharing is the one of joint hypothesis of constant preference parameter and risk sharing hypothesis. Accordingly, by rejecting the null hypothesis, it is not necessarily clear whether the assumption of constancy of parameters is not satisfied or frictions to risk sharing exist in real world. Second, in principle, the implication we exploit is free from a functional form assumption whereas implication from the deviation from the mean typically examined in the literature holds under limited types of utility functions. However, we acknowledge that our present implementation of the test uses CRRA utility function and under this assumption implications exploited in previous studies also hold.

Empirical Results

Figures 4 report the CDFs of change in total food consumption, that is a sum of purchased food consumption and imputed value of self-production, in eight ways. Panel (A) depicts the CDF by different categories of income change before and after the earthquake. In this figure, we excluded the households which responded that their income increased after the earthquake since the number of those households is small. There are four CDFs in the figure which correspond to households whose income declined more than 50 percent, income declined by 30 percent to 50 percent, income decreased by 10 percent to 30 percent and income was unchanged before and after the disaster. The differences among these CDFs are surprisingly small. The two-sample Kolmogorov-Smirnov tests of the equality of distributions do not reject the equality between the pairs of these four empirical distributions. This finding shows that complete market hypothesis is not rejected in the Yamakoshi village and household consumption was not affected by the size of the idiosyncratic income shocks.

Panel (B) describes the CDF by different house damages to housing properties. Again, we observe that distribution of the change in consumption is not affected by the degree of individual shocks to housing properties. The CDFs except the half-collapsed house (Daihankai) overlap, implying that households with larger damages to housing property and those with smaller damages face the same degree of consumption change. The sample size of the Daihankai households is small and the two-sample Kolmogorov-Smirnov test indicate the equality between the pairs of these four empirical distributions. Investigating the results for an extreme case and a modest case in Panels (C) and (D) yield analogous results.[4] Together with the finding in Panels (A) and (B), the analysis of the CDFs demonstrates that complete insurance hypothesis is consistent with data from the Yamakoshi village after the large disaster so long as we confine our attention to the implication of the complete market hypothesis on consumption.

However, recall that more than 80% felt they are liquidity constrained (Table 3). Panel (E) shows two CDFs for credit constrained and unconstrained respondents. As discussed in Section 3, we identify a household as credit unconstrained if it responded that it could borrow 10 million Yen (approximately 80,000 USD) from a bank to rebuild a house and a household as credit constrained if it answered negatively to the question. Unlike Panel (A)-(D), we notice a consistent gap in the CDFs between these two groups which is also confirmed by the two-sample Kolmogorov-Smirnov test. This gap suggests that the credit unconstrained households experienced smaller changes in consumption than the constrained households.

So far, we treat the extent of certified house damage as the exogenous source of variation. Yet, we have some evidence that income level is correlated with the degree of housing damage. In order to capture exogenous variations, we obtain geological information to measure the local magnitude of the earthquake strength. Variables we use include: distance from house to landslide; distance from valley or ridge; elevation of the terrain at the house location (above sea level); distance between the house and the closest pond; elevation at the pond location; curvature of the slope (convex or concave); distance from road; distance from stream; distance from anticline or syncline; geology

[4] The two-sample Kolmogorov-Smirnov tests also indicate the equality between the pairs of these empirical distributions.

code; degree of slope; and direction of slope. According to seismology, the propagation of quake wave occurs mainly perpendicularly to the direction of the fault line, so the damage should be greater on terrain with slope more perpendicular to the direction of the fault. In the Yamakoshi village case, the fault at the origin of the earthquake is presumed to be of NE direction with some debates. It is natural to assume that people have little knowledge about the existing fault lines. Even if they know, it is unknown which fault line is to be the epicenter. Therefore, the angle to the fault line is unobservable and can be used as an exogenous shock variable.

In order to employ geological information as exogenous shock variable, we run ordered-probit model of four degrees of damages for low/medium income group and high income group separately. In Table 4, the first column shows the result of the ordered-probit model where independent variables include only direction and degree of the slope of the ground for each house. Indeed, we can verify that the direction and the degree of slopes are correlated with intensities of damages. Notably, the dummy for the high income group is negatively related with the damage degrees. Hence, we need to split the sample according to income level. In the second and third specification for low and high income groups, respectively, the independent variables also include geological information variables shown the above as well as block dummy variables (Table 4). A null hypothesis of jointly zero coefficients of independent variables is rejected for both high and low income groups with p-values 0.000 and 0.055, respectively. Then we use the derived index to classify the high damage group with the largest 25% of the index and the low damage group with the lowest 25%. We can compare two CDFs of consumption growth rate, one for the high damage group and the other for the low damage group for each income group separately. Figure 4(F) and 4(G) show these comparisons for the low income group and the high income group, respectively. In Figure (G), while an eyeball test implies that consumption growth rate of the low damage group is stochastically dominated by that of the high damage group, Kolmogorov-Smirnov test indicate the equality between the pair. The same qualitative result holds for the high income group in Figure 4(G). Moreover, even we control for the lagged consumption level, we cannot reject the equality of distributions (see Figure 4(H))

In sum, we find that a change in consumption between before and after the

Chuetsu earthquake was not correlated with idiosyncratic shocks to household income or damages to housing. This implies that some mechanism works to attain risk sharing in the village. However, the market is not necessarily complete as we see a clear difference between credit constrained and unconstrained groups and the former suffers from larger decline in consumption. In the next section, we will explore the mechanism behind what we find in this section to uncover how villagers in Yamakoshi village coped with the damages after the event.

5. Risk Coping Measures

While the above tests inform us that there is some mechanism in place which enables consumption smoothing to some degree, the tests are silent about what the mechanism is.[5] In this section, we investigate relative importance of various insurance measures. In our data, we observe main risk coping measures directly and thus able to investigate relative importance of these strategies including the role of indemnity payments from private insurance.

Specifically, we examine quantitatively the relative importance of a wide variety of formal and informal ex ante and ex post insurance mechanisms:

(1) Public cash transfers via two routes:[6]
   1. Donation (Gienkin): publicly distributed donations
   2. Livelihood Recovery Transfers, a government cash transfer program

(2) Market mechanisms: insurance, credit, and labor markets

(3) Private transfers or co-residence: altruism vs. selfishness

(4) Self-insurance: asset and consumption reduction

Public Transfers

As has been discussed already, there are two public cash transfer programs: Donation (Gienkin), i.e. publicly distributed donations; and Livelihood Recovery

[5] Exceptions in the literature are Blundell, Pistaferri, and Preston (2002), Dynarsky and Gruber (1997), Fafchamps and Lund (2003), and Sawada and Shimizutani (2005).

[6] Government also offered temporal shelters.

Transfers, i.e., a government cash transfer program to the victims of the earthquake.

The allocation rules of these public transfers are exogenously fixed. For example, allocation of Gienkin, people's donations to various non-profit organizations, to the victims is centrally determined by a special public committee. To verify this, we regress each public transfers on damage variables. Table 5 shows the estimation results which confirm that the allocation rules are exogenously given.

Market Mechanisms: *Insurance, Credit, and Labor Markets*

As to the formal insurance contract, amazingly, the earthquake insurance participation rate before the earthquake was 82.2% and average premium payments were 100,000 Yen per year. Yet, this high participation rate may not be attributed to people's expectation of an earthquake. Rather, this is mainly because majority of household participated in the housing insurance program provided by the farmers' cooperatives and the program automatically includes the earthquake insurance contract.

As a second market mechanism of risk-coping, with an access to credit market, households can absorb shocks by reallocating future resources to today's consumption [Besley (1995); Eswaran and Kotwal (1989)]. Yet, households may be constrained from borrowing for a variety of reasons such as the lack of collateral [Garcia, et al. (1997); Hayashi (1985); Horioka and Kohara (1999); Jappelli (1990); Jappelli et al. (1998); Lee and Sawada (2007); Olney (1999); Zeldes (1989)]. By incorporating carefully worded questions, we will be able to identify credit constraints directly.

Finally, labor market may act as an important ex post insurance mechanism. After facing negative income shocks, household members can participate in the labor market additionally [Dynarski and Gruber (1997); Kochar (1999; 1999); Jacoby and Skoufias (1997)]. We will save this issue for the future study because of data limitation.

Private transfers or co-residence

Private transfers or co-residence among agents can act as an effective coping device. The existing related studies argue whether these transfer behaviors are motivated by altruism or self-interests [Cox (1987); Cox and Fafchamps (2007); Altonji, Hayashi, and Kotlikoff (1992, 1997); Rosenzweig and Stark (1989)]. Theoretically, mutual insurance, i.e., informal arrangements of state-contingent transfers, can be self-enforcing in a (infinitely) repeated game framework [Coate and Ravallion (1993); Kimball (1992); Kocharlakota (1996)].

Figure 5(a) shows a CDF of the amount of private transfers after the earthquake drawn separately for those who moved into the temporal shelters and for those who live outside of the shelters. Largely speaking, families in the former group have received a larger amount of transfers than families in the latter group especially if we limit the maximum amount of private transfers to one million yen. This suggests that, within an extended family, providing co-residence may be regarded as a substitute for sending private transfers.

Figures 5(b) and 5(c) show CDFs of private transfers by home damage status. These figures are drawn only for the home owners before the earthquake. In Figure 5(b), those who encountered a larger damage (collapsed home) receive less private transfers than the people with half-collapsed house especially if we limit the amount of private transfers to one million yen. On the other hand, between half-collapse damage and minor damage, private transfers seem to be sensitive to the degree of damages. Considering the fact that the home owners of a collapsed house due to the earthquake received a large amount of public transfers (Table 5), transfer donors seem to take into account of public transfers when they provide transfers. If we employ the theoretical framework of Becker (19XX) and Cox (1987), Figure 5 may reveal that private transfers are motivated by altruism.

Self-Insurance: Asset and Consumption Reduction

There are several ways to utilize self-insurance mechanisms in order to cope with negative income and asset shocks. First, households can cope with negative shocks by changing the quality and composition of food expenditure and/or reducing luxury expenditure [Dynarski and Gruber (1997); Olney (1999); Frankenberg, Thomas, and Beegle (1999); Kang and Sawada (2008)].

Second, households can accumulate financial and physical assets as a precautionary device against unexpected income shortfalls [Banks and Blundell (2001); Carroll and Kimball (2006); Dynan (1993); Gourinchas and Parker (2002); Hori and Shimizutani (2006); Zeldes (1989)]. Then dissaving becomes an important coping instrument [Fafchamps, Czukas and Udry (1997); Rosenzweig and Wolpin (1993)].

6. Estimating the average effect of damages on risk coping behavior

We will examine how different households with different damages use the above-mentioned four routes of risk coping. The main difficulty is that the amount of damage depends on the amount of assets each household owns and extent to which each methods are employed also depends on the assets each household own creating an endogeneity problem.

The only exception is the public cash transfer in this instance. There is a deterministic rule that determined the amount of public cash transfer that did not depend on the amount of asset each household owns but depends only on the extent of the damage to the house (5 levels including no damage) and the number of household members. We will present description about the temporary shelter and the probability of taking it up. Then, we will discuss private transfer inclusive of the co-residencies.

An approach to handle the endogeneity problem

We assume that a dependent variable Y, which represents the intensity of a coping behavior, depends on a vector X, the amount of economic damage D, and a stochastic term ω:

$$Y = m(X, D, \omega). \tag{2}$$

In turn, the extent of the shock Z affects the amount of economic damage D so that $D = D(Z)$. Yet, we assume that the shock Z does not affect (X, ω). Although not explicitly written, we assume that D may be affected by (X, ω).

Under this setup, note that Arai and Ichimura (2008) showed that[7]

$$\begin{aligned} E(Y \mid Z = z) &= E[m(X, D(z), \omega) \mid Z = z] \\ &= E[m(X, D(z), \omega)], \end{aligned} \tag{3}$$

[7] This framework allows a simple causal interpretation to the local average treatment effect (LATE) parameter of Angrist and Imbens (1994) when treatment variable is continuous, linking the program evaluation literature and the nonseparable simultaneous equation literature.

so that

$$E(Y \mid Z = z) - E(Y \mid Z = z') = E[m(X, D(z), \omega) - m(X, D(z'), \omega)]. \qquad (4)$$

This implies that the part, $E(Y \mid Z = z) - E(Y \mid Z = z')$, identifies the average causal effect of the damage change from $D(z')$ to $D(z)$ on Y. While eventually we want to use the geological measure of the earthquake for Z, for now we set Z to be one of the five observable categories of the officially certified damages to the house. In order to capture the per yen effect of the damage, we examine

$$\frac{E(Y \mid Z = z) - E(Y \mid Z = z')}{E(D \mid Z = z) - E(D \mid Z = z')}. \qquad (5)$$

Note that this effect can be understood as a generalization of the local average treatment effect (LATE) of Angrist and Imbens (1994) for a continuous treatment variable, D (Arai and Ichimura, 2008). In order to examine the per yen effect of the damage on various subgroups, we condition on certain variables such as asset level, income, and age. Denoting the discrete subgroup indicator by G, the relationship between the conditioned version of (5) is

$$\begin{aligned} &\frac{E(Y \mid Z = z) - E(Y \mid Z = z')}{E(D \mid Z = z) - E(D \mid Z = z')} \\ &= \sum_g \frac{E(Y \mid Z = z, G = g) - E(Y \mid Z = z', G = g)}{E(D \mid Z = z, G = g) - E(D \mid Z = z', G = g)} \\ &\times \Pr(G = g) \frac{E(D \mid Z = z, G = g) - E(D \mid Z = z', G = g)}{E(D \mid Z = z) - E(D \mid Z = z')} \end{aligned} \qquad (6)$$

where independence of ω and Z given G and X is assumed.

Damage Estimates

In order to estimate the value of damages, we included the following items:

1. Housing damages: information on the ownership, the size, the official damage

certificates, and direct evaluation of the damages

2. Farm damages: physical size of the damages evaluated by the village average farm profits, i.e., 8,000 Yen (70 USD) per *are* times 1.5 years.
3. Office damages: direct (subjective) evaluation of the damages
4. Health damages: a question about the direct uncovered health/medical expenditures.

Figure 7 represents a CDF of the total gross amount of all damages. Figure 8 shows the amount of gross damages recovered by different coping mechanisms, i.e., receiving donations, receiving government transfers, receiving indemnity payments, receiving private transfers, and reducing consumption. Examination of each risk coping measures reveal that with all the employed measures, there are more than 20% and 40% of households whose net damage exceed 10 million yen and 5 million yen, respectively. This indicates the magnitude of the shocks Yamakoshi experienced.

Figures 9-14 represent gross damages and the recovered amount by different coping strategies for each home damage and credit constraint status. According to these figures, the most important measure to cope with the earthquake risk was earthquake insurance, followed by donation and government transfer especially in the case of serious damages. In contrast, the private cash transfer plays relatively and absolutely a small role. The reduction in consumption and dissaving are measures employed only by relatively well-off households with annual income of 8 million yen.

Similar tendencies can be confirmed using the concept of per Yen effect of the damages defined by equation (5). Tables 6 represent the results of computing aggregated per Yen effect in equation (5) as well as decomposing per Yen effect for each subgroup, i.e., the first part of equation (6):

$$\frac{E(Y \mid Z=z, G=g) - E(Y \mid Z=z', G=g)}{E(D \mid Z=z, G=g) - E(D \mid Z=z', G=g)}. \qquad (7)$$

As can be seen from Table 6, earthquake insurance indemnity payments were the most important means. Allocation of donations and government transfers were effective per damage. On average, if the level of house damage changes from half-collapse to collapse, around sixty nine percent of damaged value is covered by these means where half of these compensations come from donations. In contrast, insurance payments are more effective for minor damage: if the level of house damage changes from minor damage to half-collapse, around thirty eight percent of damaged value is covered by insurance indemnity payments. These effects are particularly strong to the middle and low income groups. In contrast, sensitivity of the private cash transfers against earthquake damages is negligible except those who have kinship network. The finding is similar to the estimate by Altonji et al. (1997).

Table 7 shows the results based on the estimated damage index using the framework of equation (7). In order to compute the effectiveness of each risk coping instruments, we use the case of a change from the bottom 25% damage to the top 25% damage. Private transfers are negative, suggesting that these transfers were not helpful in weathering the damages. While dissaving and borrowing of the high income group responded against damages, the magnitudes seem to be negligible. In contrast, the amounts of insurance indemnity payments, the donation, and the livelihood transfers, are amounted to 12-13%, 12%, 10-17%, respectively, of the damages.

6. Concluding Remarks

We investigate whether and how people were insured against unexpected losses caused by the Chuetsu earthquake in 2004 using unique data exclusively collected for this study in Yamakoshi village. While we found that some degree of consumption smoothing is observed in our data, liquidity constraints seem to inhibit the consumption risk sharing. Examination of each risk coping measures reveal that with all the employed measures, there are more than 22 percent of households whose net damage exceed 10 million yen. These findings seem to suggest a potential caveat of the standard complete market test based on the changes in consumption. Our unique data revealed that the most important measure to cope with the earthquake risk was earthquake insurance, followed by donation and government transfer. On the other hand, the private cash transfer plays relatively and absolutely a small role. The reduction in consumption and dissaving are measures employed only by relatively well-off households with annual income of at least eight million yen.

Future studies should address two important issues. First, since we have some evidence that income level is correlated with the degree of housing damage, we need to employ geological information, rather than damage information, about the ex ante riskiness of the location of each of the household's occupied house. Second, in addition to examining the marginal distributions via mean and quantile values, we plan to investigate multivariate quantiles. This enables us to examine trade-off among various risk coping measures.

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Table 1(A) Damages to Housing Properties

	Blocks	Evacuation Order	# Response	Collapsed	Almost-Collapsed	Half-Collapsed	Minor Damages
1	Tanesuhara	Expired (2005/7/22)	168	0.119	0.083	0.482	0.315
2	Mushigame	Expired (2005/7/22)	127	0.276	0.205	0.378	0.142
3	Takezawa	Expired (2005/7/22)	74	0.405	0.095	0.270	0.230
4	Manaihira	Expired (2005/7/22)	22	0.727	0.045	0.136	0.091
5	Shoubu	Expired (2005/7/22)	4	0.500	0.000	0.250	0.250
6	Yamanaka	Expired (2005/7/22)	12	0.583	0.000	0.333	0.083
7	Yubu	Expired (2006/8/18)	16	0.625	0.063	0.313	0.000
8	Katsuraya	Expired (2005/7/22)	36	0.556	0.167	0.250	0.028
9	Kajigane	Expired (2007/4/1)	23	1.000	0.000	0.000	0.000
10	Kigomo	Expired (2007/4/1)	21	0.905	0.048	0.048	0.000
11	Komatsugura	Expired (2005/7/22)	20	0.600	0.150	0.150	0.100
12	Okubo	Expired (2007/4/1)	15	0.867	0.000	0.133	0.000
13	Iketani	Expired (2007/4/1)	29	0.862	0.000	0.000	0.138
14	Naranoki	Expired (2007/4/1)	28	0.893	0.000	0.107	0.000
	Total		595	0.432	0.099	0.303	0.166

(Source) Authors’ calculation from our survey.

Table 1(B) Damages to workplaces and personals

		Damages to workplaces			Damages to persons			
	Blocks	Damages to farms	Damages to offices	Damages to carp ponds	Family member dead	Head injured	Family member (except head) injured	Head unemployed
1	Tanesuhara	0.74	0.11	0.20	0.05	0.10	0.07	0.29
2	Mushigame	0.65	0.17	0.43	0.03	0.09	0.12	0.43
3	Takezawa	0.55	0.15	0.53	0.04	0.04	0.12	0.30
4	Manaihira	0.82	0.18	0.64	0.00	0.05	0.00	0.41
5	Shoubu	0.25	0.25	0.25	0.00	0.00	0.00	0.25
6	Yamanaka	0.67	0.00	0.58	0.00	0.08	0.08	0.50
7	Yubu	0.94	0.13	0.63	0.13	0.25	0.13	0.38
8	Katsuraya	0.64	0.19	0.36	0.11	0.11	0.17	0.36
9	Kajigane	0.83	0.04	0.65	0.09	0.17	0.13	0.39
10	Kigomo	0.90	0.19	0.38	0.00	0.10	0.29	0.81
11	Komatsugura	0.90	0.05	0.45	0.10	0.15	0.15	0.25
12	Okubo	0.93	0.20	0.53	0.00	0.13	0.13	0.67
13	Iketani	0.93	0.07	0.28	0.07	0.07	0.10	0.34
14	Naranoki	1.00	0.11	0.29	0.07	0.14	0.14	0.32
	Total	0.73	0.13	0.38	0.05	0.10	0.11	0.37

(Source) Authors' calculation from our survey.

Table 2 Income Change before and after the Earthquake

	Blocks	Decreased >50%	Decreased 30-50%	Decreased 10-30%	Unchanged	Increased 10-30%	Increased 30-50%	Increased >50%
1	Tanesuhara	0.22	0.16	0.21	0.36	0.04	0.01	0.00
2	Mushigame	0.31	0.15	0.18	0.38	0.02	0.02	0.00
3	Takezawa	0.23	0.17	0.07	0.51	0.00	0.00	0.01
4	Manaihira	0.29	0.05	0.19	0.43	0.05	0.00	0.00
5	Shoubu	0.25	0.25	0.25	0.25	0.00	0.00	0.00
6	Yamanaka	0.25	0.17	0.08	0.50	0.00	0.00	0.00
7	Yubu	0.21	0.00	0.29	0.50	0.00	0.00	0.00
8	Katsuraya	0.19	0.03	0.16	0.52	0.03	0.06	0.00
9	Kajigane	0.23	0.09	0.18	0.50	0.00	0.00	0.00
10	Kigomo	0.68	0.05	0.16	0.11	0.00	0.00	0.00
11	Komatsugura	0.24	0.18	0.18	0.35	0.06	0.00	0.00
12	Okubo	0.42	0.00	0.25	0.33	0.00	0.00	0.00
13	Iketani	0.31	0.12	0.23	0.35	0.00	0.00	0.00
14	Naranoki	0.19	0.19	0.26	0.30	0.07	0.00	0.00
	Total	0.27	0.13	0.18	0.38	0.03	0.01	0.01

(Source) Authors' calculation from our survey.

Table 3. Descriptive Statistics of the Main Variables

	Obs	Mean	Std. dev.
Household characteristics			
Age of the head	593	65.057	(12.296)
Dummy=1 if the head is junior/senior high school graduate	597	0.652	
Dummy=1 if the head is wage earners	597	0.283	
Dummy=1 if the head is unemployed or retired	597	0.474	
Dummy=1 if the head is farmer	597	0.147	
Dummy=1 if the head is self-employed	597	0.054	
Number of sons	568	1.206	(1.019)
Number of daughters	570	1.288	(1.076)
Number of working sons out of Yamakoshi	558	0.658	(0.847)
Number of working daughters out of Yamakoshi	555	0.802	(0.998)
Dummy=1 if own house before earthquake	597	0.953	
Size of the land own for residence (in 3.3 m^2)	597	118.213	(117.914)
Size of the house (in 3.3 m^2)	597	43.920	(28.845)
Dummy=1 if own farmland	597	0.871	
Size of farmland (in are)	597	34.742	(75.573)
Size of carp breeding pond (in are)	597	24.447	(75.766)
Dummy=1 if credit constrained	570	0.812	
Dummy=1 if moved in the shelter	597	0.782	
Amount of monetary and in-kind private transfers (in 10,000Yen)	489	84.900	(175.559)
Dummy=1 if participate in earthquake insurance	583	0.822	
Damages caused by the earthquake			
Dummy=1 if the house collapsed (zenkai)	597	0.432	
Dummy=1 if major damage to the house (daihankai)	597	0.099	
Dummy=1 if moderate damage to the house (hankai)	597	0.303	
Dummy=1 if a member died	597	0.050	
Dummy=1 if the head hospitalized	597	0.097	
Dummy=1 if other member hospitalized	597	0.111	
Dummy=1 if the head became unemployed	597	0.369	
Dummy=1 if the farmland damaged	597	0.732	
Dummy=1 if business damaged	597	0.131	
Dummy=1 if carp breeding pond damaged	597	0.382	
Coping strategies			
Dummy=1 if coped by dissaving	597	0.698	
Dummy=1 if coped by private transfers	597	0.518	
Dummy=1 if coped by receiving insurance	597	0.486	
Dummy=1 if coped by public transfers	597	0.742	
Dummy=1 if coped by borrowing	597	0.044	
Dependent variables			
Growth rate of total consumption	499	0.193	(0.397)
Growth rate of self-consumption (imputed value)	454	-0.649	(0.585)

Table 4 Determinants of house damages using geological information

Variables		All			Low income			High Income		
		Coef.	Std. Err.	P>|z|	Coef.	Std. Err.	P>|z|	Coef.	Std. Err.	P>|z|
Dummy=1 if annual income< 3million yen	low	0.190	0.130	0.145						
Dummy=1 if annual income>8 million yen	high	-0.292	0.160	0.069						
Distance from house to landslide	hous_land				-0.002	0.001	0.091	0.003	0.003	0.323
Distance from valley	dist_vally				-0.001	0.001	0.166	0.001	0.002	0.572
Distance from ridge	dist_ridge				0.000	0.002	0.814	-0.003	0.004	0.497
Location index	Loca_index				0.009	0.549	0.987	-1.080	1.415	0.445
Elevation of the terrain at the house location (above sea level)	elevation				0.001	0.006	0.813	-0.017	0.012	0.144
Distance between the house and the closest pond	hous_ike				0.000	0.001	0.937	0.004	0.003	0.268
Elevation at the pond location	ike_elev				-0.001	0.004	0.801	0.008	0.008	0.292
Curvature of the slope (convex or concave)	curva08				-0.072	0.035	0.040	-0.020	0.093	0.830
Distance from road	dist_road				-0.003	0.003	0.335	0.000	0.007	0.958
Distance from stream	dist_strea				0.000	0.001	0.657	0.002	0.003	0.384
Distance from the fault	dist_fault				0.000	0.000	0.870	0.000	0.001	0.936
Geology code 4	geology4				-0.018	0.302	0.951	-0.141	0.600	0.814
Dummy =1 if Slope toward NE	northeast	-0.296	0.350	0.398	0.116	0.477	0.808	-1.264	0.972	0.193
Dummy =1 if Slope toward E	east	-0.473	0.318	0.136	-0.140	0.435	0.747	-0.721	1.354	0.594
Dummy =1 if Slope toward SE	southeast	-0.086	0.321	0.788	-0.012	0.435	0.979	-1.278	1.121	0.254
Dummy =1 if Slope toward S	south	0.360	0.347	0.300	0.804	0.479	0.093	-1.004	1.272	0.430
Dummy =1 if Slope toward SW	southwest	0.095	0.338	0.778	0.204	0.481	0.671	-1.340	0.998	0.179
Dummy =1 if Slope toward W	west	0.533	0.343	0.120	-0.001	0.495	0.998	0.871	1.074	0.417
Dummy =1 if Slope toward NW	northwest	0.605	0.375	0.107	-0.028	0.517	0.957	0.791	1.370	0.564
Slope toward N * degree of slope	snorth	0.045	0.026	0.086	0.003	0.035	0.935	0.014	0.075	0.849
Slope toward NE * degree of slope	snortheast	0.051	0.033	0.124	-0.020	0.041	0.636	0.174	0.108	0.107
Slope toward E * degree of slope	seast	0.060	0.023	0.010	0.030	0.034	0.376	-0.103	0.146	0.481
Slope toward SE * degree of slope	ssoutheast	0.041	0.017	0.016	0.001	0.025	0.955	0.076	0.054	0.160
Slope toward S * degree of slope	ssouth	0.028	0.020	0.177	-0.034	0.025	0.176	0.063	0.112	0.570
Slope toward SW * degree of slope	ssouthwest	0.043	0.019	0.026	-0.017	0.027	0.531	0.133	0.055	0.015
Slope toward W * degree of slope	swest	0.026	0.019	0.177	0.020	0.027	0.469	-0.082	0.069	0.233
Slope toward NW * degree of slope	snorthwest	-0.008	0.022	0.725	-0.021	0.029	0.469	-0.074	0.097	0.450
Sample size			591			388			100	
Joint test of zero coefficients: Chi-sq			74.94			182.61			55.27	
[p-value]			[0.0000]			[0.0000]			[0.0547]	
Pseudo R2			0.0507			0.1924			0.2188	

Table 5
Allocation Rules of Donations and Government Livelihood Recovery Transfers

	Dependent variable: Total Donations publicly allocated (ten thousand yen)				Dependent variable: Government's livelihood recovery transfers (ten thousand yen)			
	Sample Statistics		Regression results		Sample Statistics		Regression results	
	Mean	S.D.	Coefficients	S.E.	Mean	S.D.	Coefficients	S.E.
	243.60	175.29			117.86	125.68		
Collapsed (zenkai)	0.44	0.50	398.40	2.05	0.44	0.50	241.84	3.31
Almost collapsed (daikibo hankai)	0.10	0.30	198.58	2.13	0.10	0.30	97.93	3.74
Half-collapsed (hankai)	0.31	0.46	46.67	2.04				
Low income dummy (takes 1 if income is less than 5 mil. Yen)							59.02	4.35
Family size	3.03	1.71	3.03	0.18	3.03	1.71	2.80	1.13
Constant			27.16	2.39			-44.98	5.92
# of sample			592				592	
R^2			0.9976				0.9212	

Table 6
Per Yen Effect of the Damages on Different Coping Strategies by Different Groups

	Per total damage in Yen		Per net damage in Yen	
	From Half-Collapsed (z) to Collapsed (z')	From Minor Damges (z) to Half-Collapsed (z')	From Half-Collapsed (z) to Collapsed (z')	From Minor Damges (z) to Half-Collapsed (z')
Amount of donation received				
Total amount	0.3441	0.0484		
<By income level>				
Lowest income level	0.3322	0.0487		
Middle income level	0.6097	0.0458		
Highest income level	0.2962	0.0500		
Amount of the government's livelihood recovery transfers received				
Total amount	0.2446	0		
<By income level>				
Lowest income level	0.2750	0		
Middle income level	0.2580	0		
Highest income level	0.1241	0		
Insurance indemnity payments received				
Total amount	0.1096	0.3766		
<By income level>				
Lowest income level	0.1188	0.3760		
Middle income level	0.0915	0.3438		
Highest income level	0.0737	0.3969		

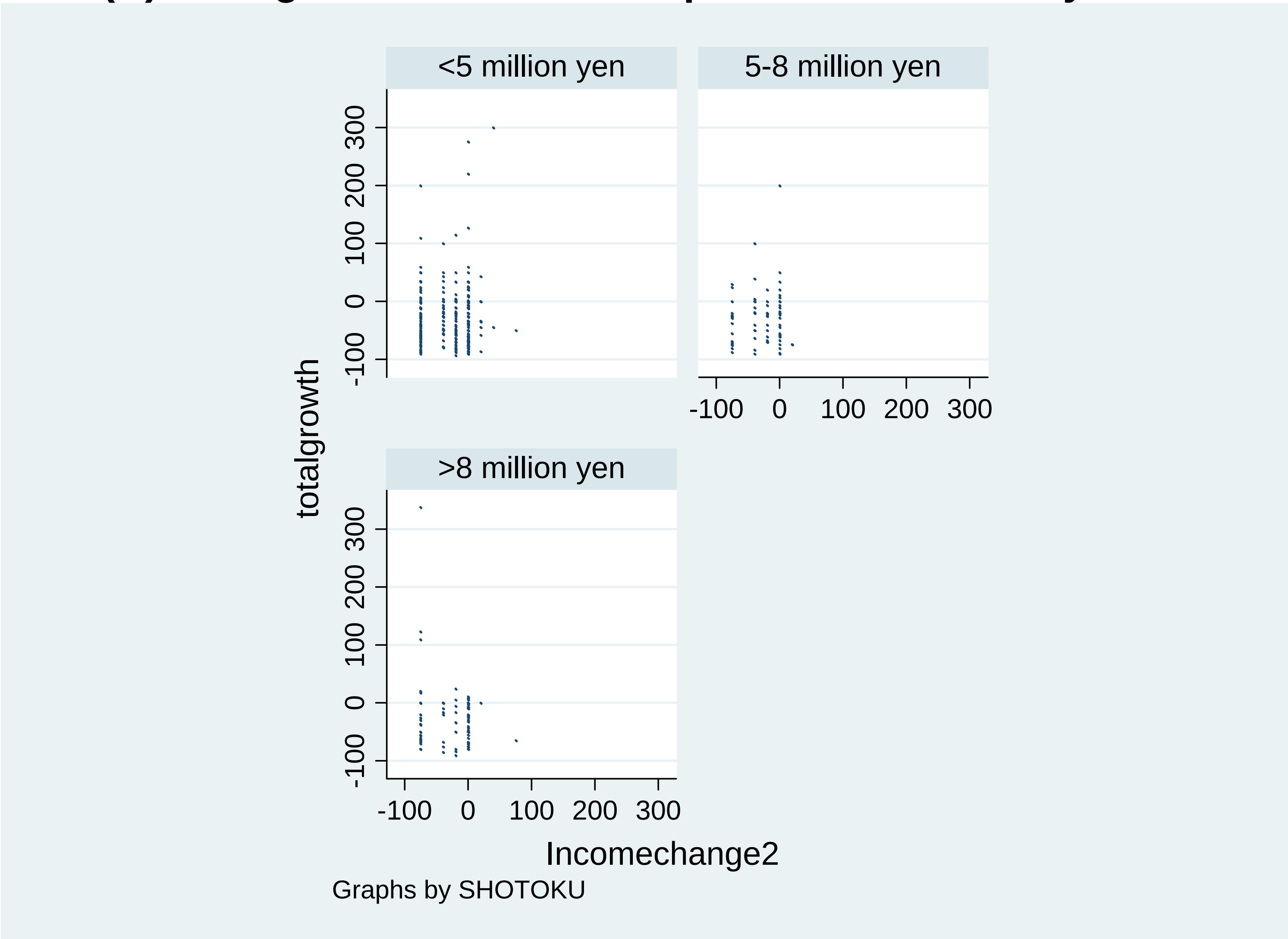
Table 6 (continued) Per Yen Effect of the Damages on Different Coping Strategies by Different Groups

	Per total damage in Yen		Per net damage in Yen	
	From Half-Collapsed (z) to Collapsed (z')	**From Minor Damges (z) to Half-Collapsed (z')**	**From Half-Collapsed (z) to Collapsed (z')**	**From Minor Damges (z) to Half-Collapsed (z')**
Private Transfers — Total amount	-0.0056	0.0011	-0.0018	0.0196
<By asset level>				
Lowest asset level	0.0254	0.0309	-6.1901	0.0518
Middle asset level	-0.0027	-0.0049	-0.0075	-0.0112
Highest asset level	-0.0013	0.0156	-0.0028	0.0267
<By income level>				
Lowest income level	0.0031	0.0155	0.0113	0.0270
Middle income level	0.0136	-0.0095	0.3329	-0.0156
Highest income level	-0.0402	0.0180	-0.0796	0.0326
<By private network>				
W/ Sons and brothers outside	0.0116	0.0160	0.0260	0.0346
(Old respondents only; age>65)	0.0208	0.0059	0.0358	0.0165
<By occupation>				
Salaried workers	-0.0239	0.0087	-0.2414	0.0146
Agriculture	-0.0075	0.0338	-0.0165	0.0533
Business owners	0.0254	-0.0006	0.0557	-0.0011
Out of work	-0.0011	0.0070	-0.0037	0.0127
Proportion of respondents who claimed the importance of self-insurance (by income group)				
Total	6.3103×10^{-7}	2.989×10^{-5}		
Lowest income level	2.0876×10^{-6}	9.607×10^{-5}		
Middle income level	-0.0003	5.052×10^{-5}		
Highest income level	7.7576×10^{-5}	-0.0001		
Proportion of respondents who claimed the importance of borrowing (by income group)				
Total	4.8204×10^{-5}	2.453×10^{-5}		
Lowest income level	-3.141×10^{-5}	2.442×10^{-5}		
Middle income level	-9.656×10^{-5}	5.052×10^{-5}		
Highest income level	6.8956×10^{-5}	0		
Consumption change — Total amount	0.0045	0.0074		
<By income level> Lowest income level	0.0025	-0.0019		
Middle income level	0.0327	-0.0203		
Highest income level	-0.0257	0.0403		

Table 7
Per Yen Effect of the Integrated Damages on Different Coping Strategies by Different Groups
For a change from the bottom 25% damage to the top 25% damage

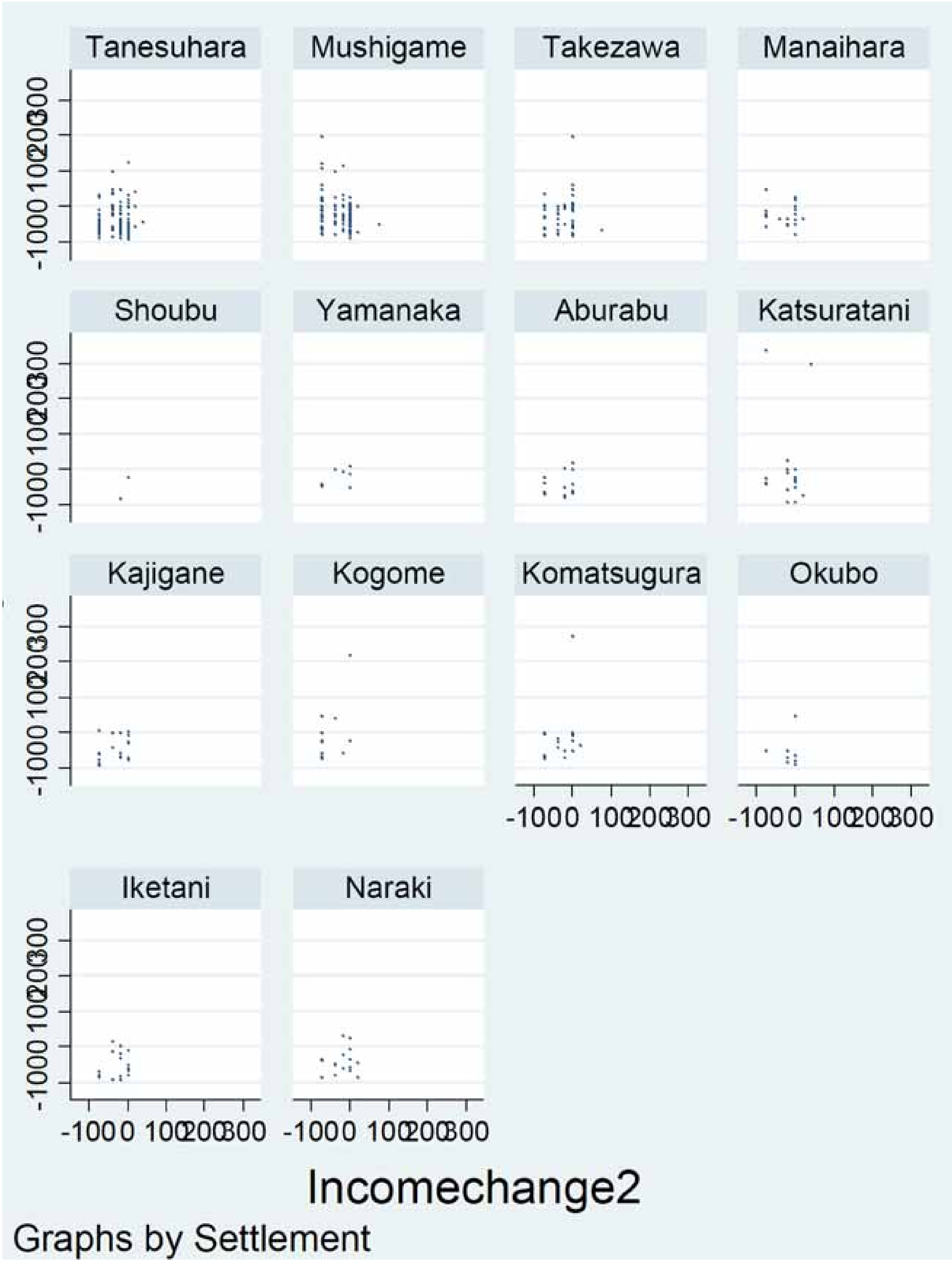
	Per Yen Effect
Amount of donation received	
Lowest income level	0.1157
Highest income level	0.1228
Amount of the government's livelihood recovery transfers received	
Lowest income level	0.1769
Highest income level	0.0933
Insurance indemnity payments received	
Lowest income level	0.1579
Highest income level	0.1217
Private Transfers	
Lowest income level	-0.0029
Highest income level	-0.0185
Proportion of respondents who claimed the importance of self-insurance (by income group)	
Lowest income level	-2.8×10^{-5}
Highest income level	9.24×10^{-6}
Proportion of respondents who claimed the importance of borrowing (by income group)	
Lowest income level	-3.2×10^{-5}
Highest income level	0
Consumption change	
Lowest income level	0.00127
Highest income level	0.001154

Figure 1 (A) Changes in Food Consumption and Income by Income Class



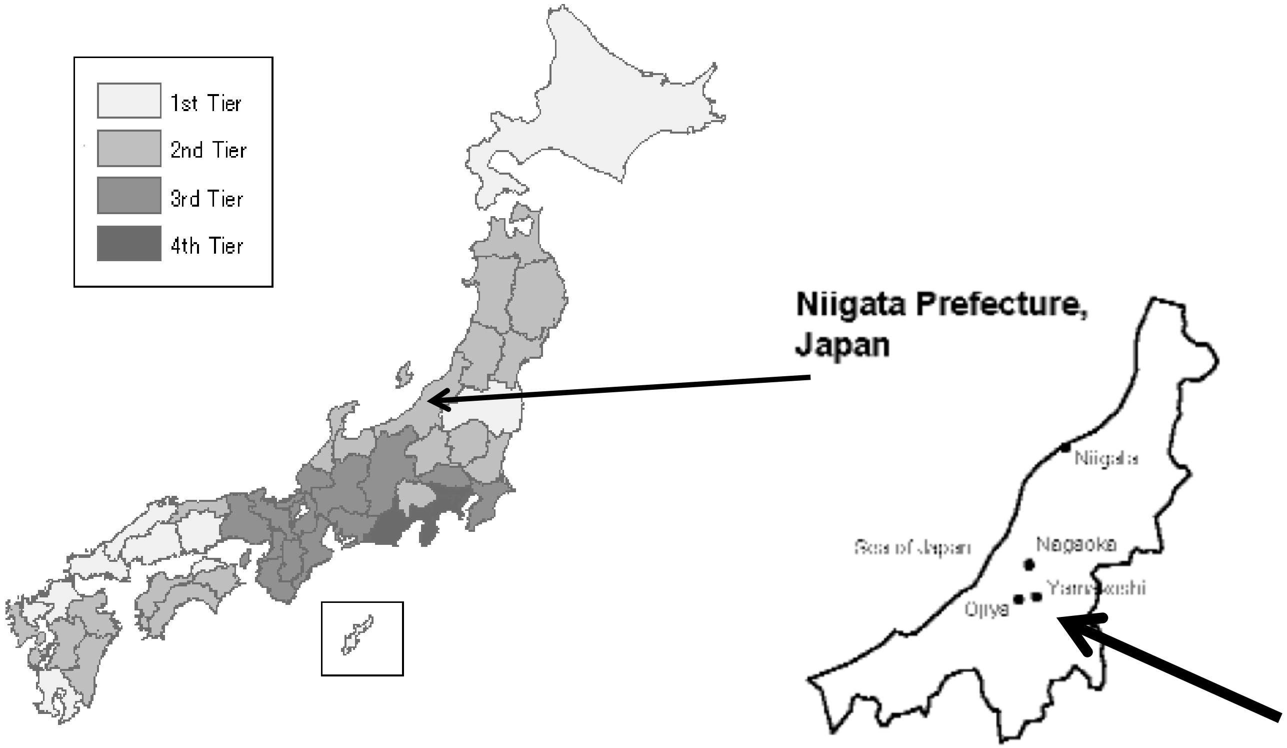
Note) Figures show the relationships between income change in % (horizontal axis) and consumption change rate in % (vertical axis)

Figure 1 (B) Changes in Food Consumption and Income by Blocks



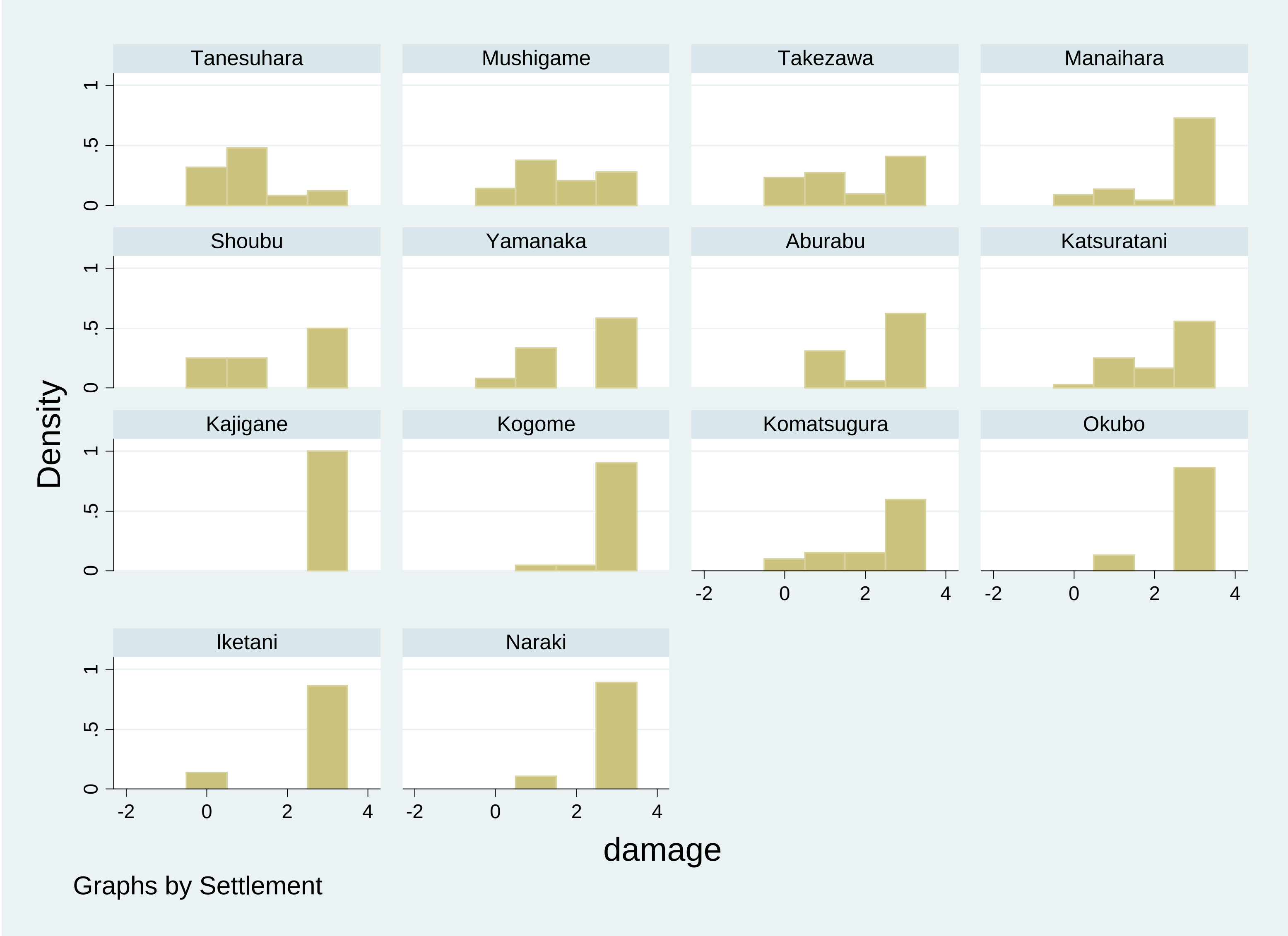
Note) Figures show the relationships between income change in % (horizontal axis) and consumption change rate in % (vertical axis)

Figure 2
Geographical Distribution of Earthquake Insurance Premium in Japan and *Yamakoshi* Village



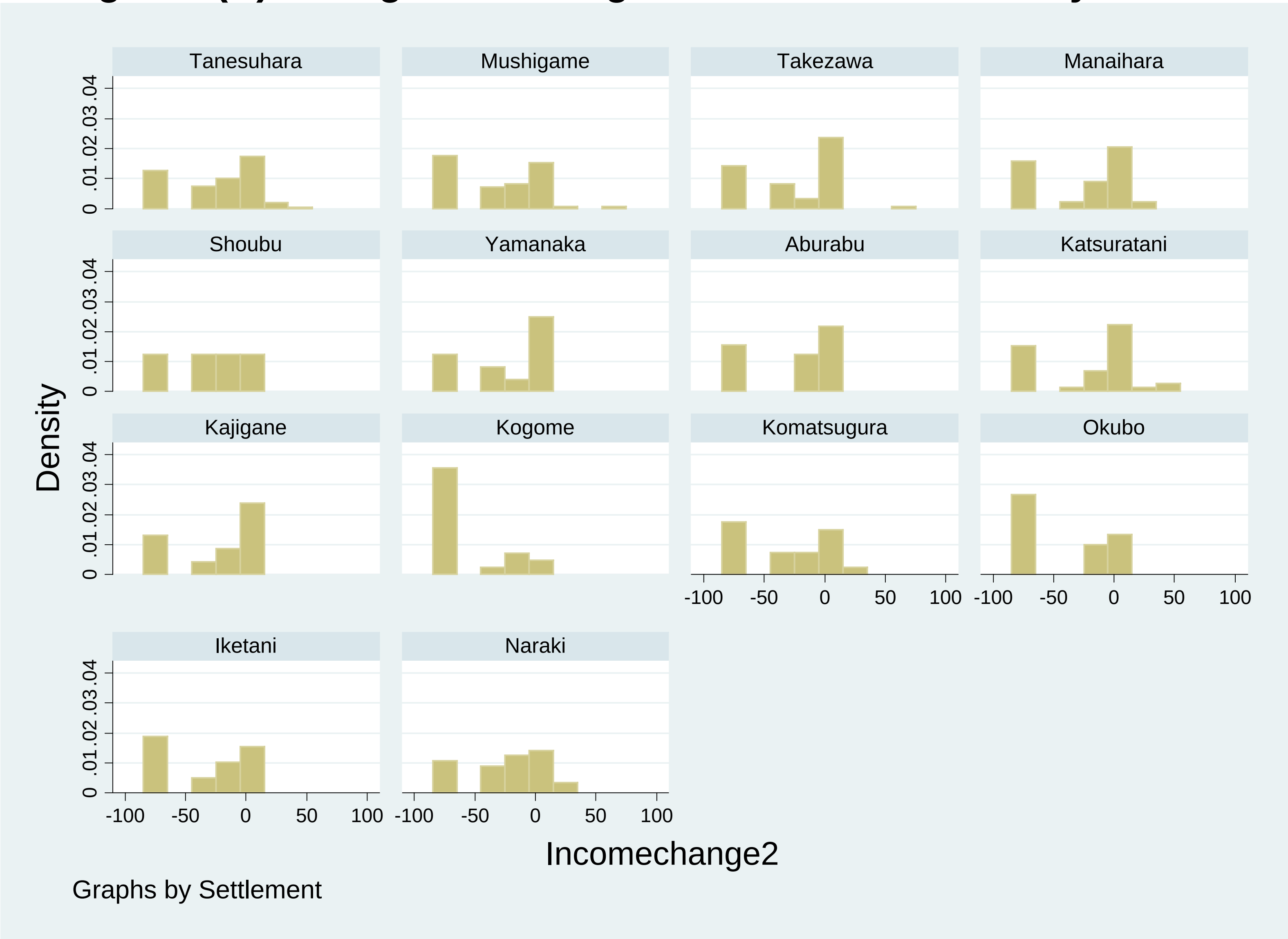
Source: Ministry of Finance: The 4th tier represents the highest insurance premium.

Figure 3(A) Histograms for Degree of Housing Damage by Blocks



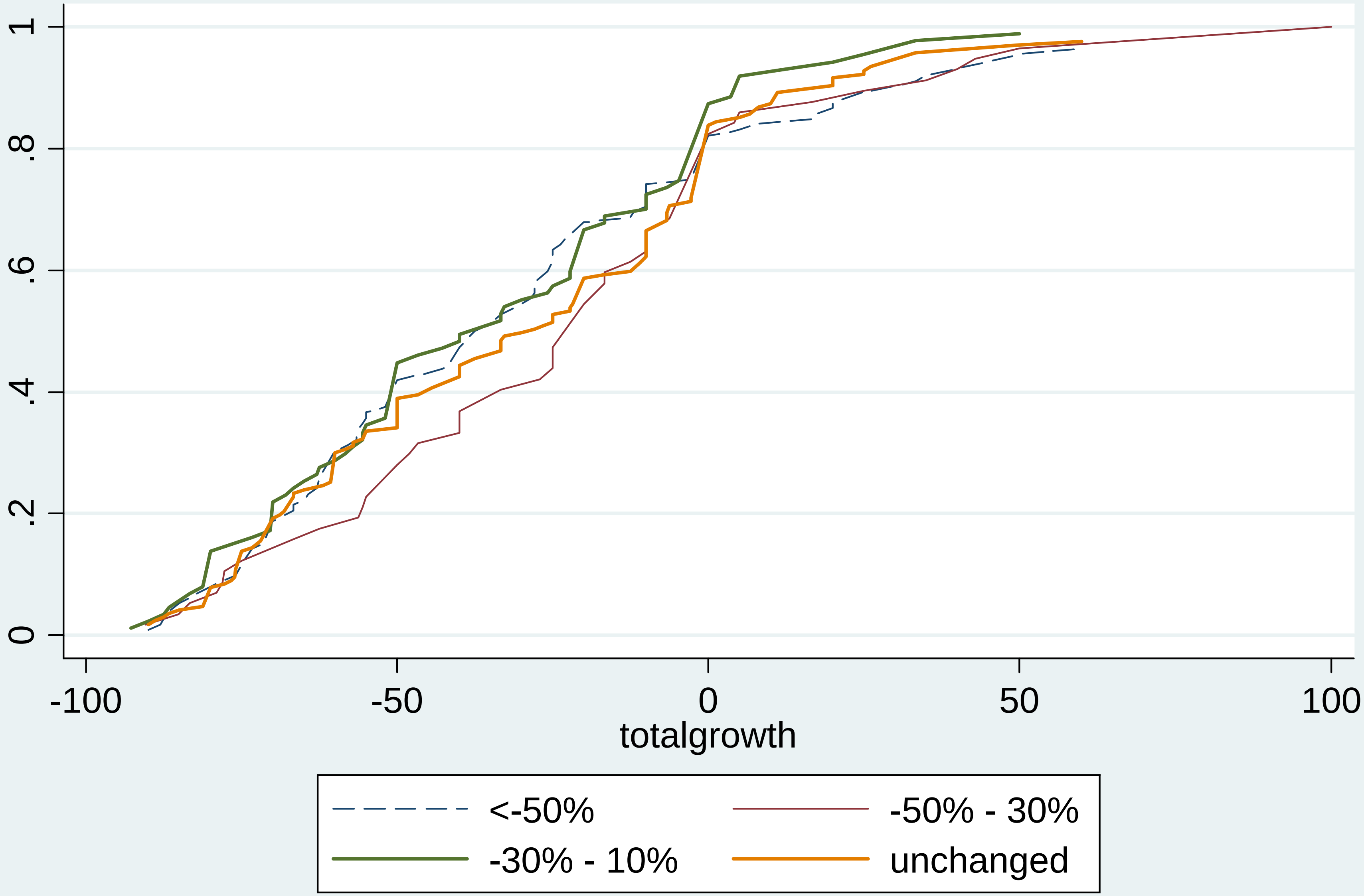
Note) Horizontal axis represents the degree of housing damages; 3=Collapsed (Zenkai); 2=Almost-collapsed (Daihankai); 1=Half-collapsed (Hankai); 0=Minor damages (Keibi Sonshou).

Figure 3(B) Histograms of Degree of Income Shocks by Blocks



Note) Horizontal axis represents the rate of income change in %.

Fig. 4 (A) CDF of consumption growth rate by income change



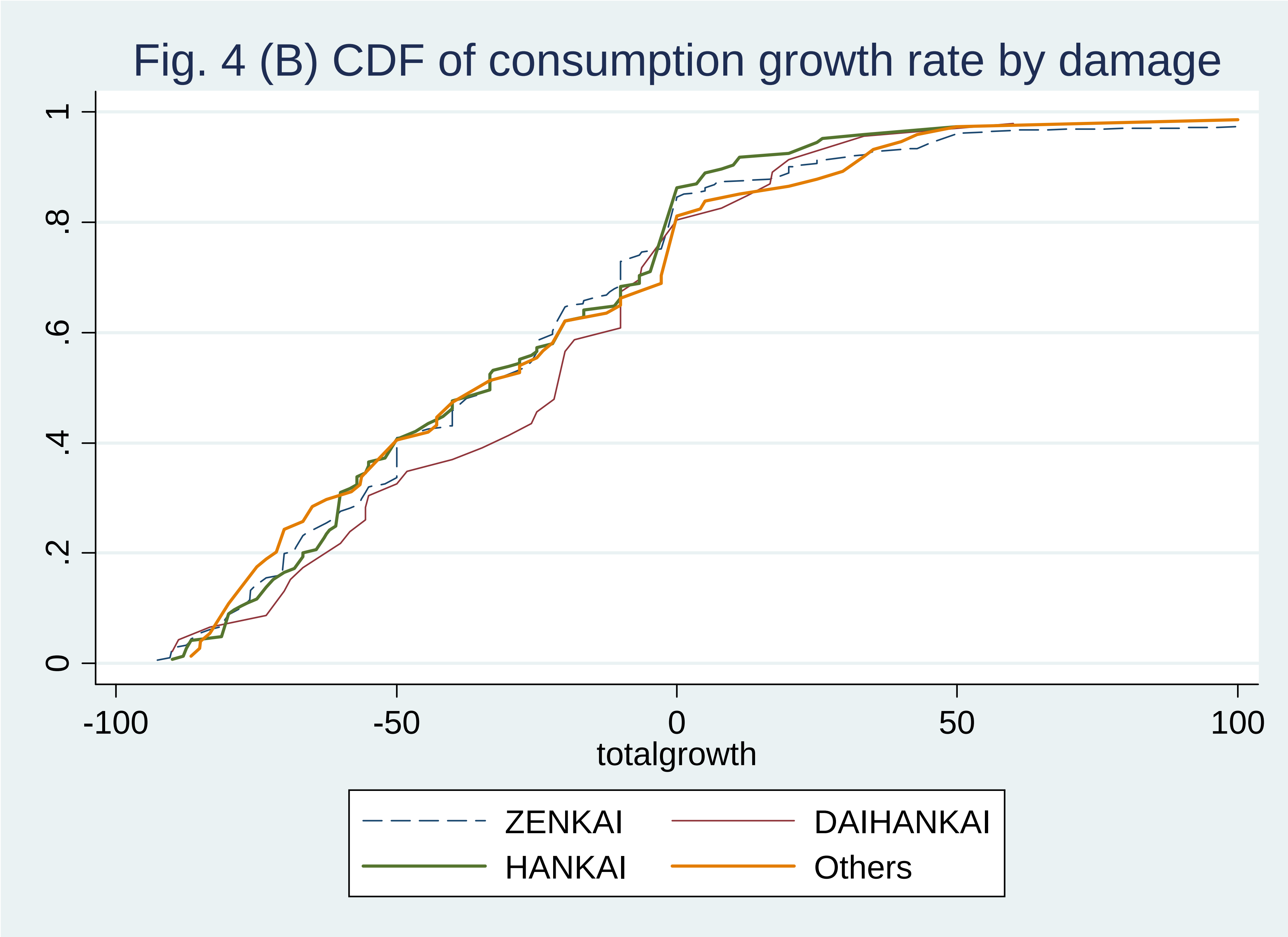


Fig. 4 (B) CDF of consumption growth rate by damage
0
.2
.4
.6
.8
1
-100
-50
0
50
100
totalgrowth
ZENKAI
DAIHANKAI
HANKAI
Others

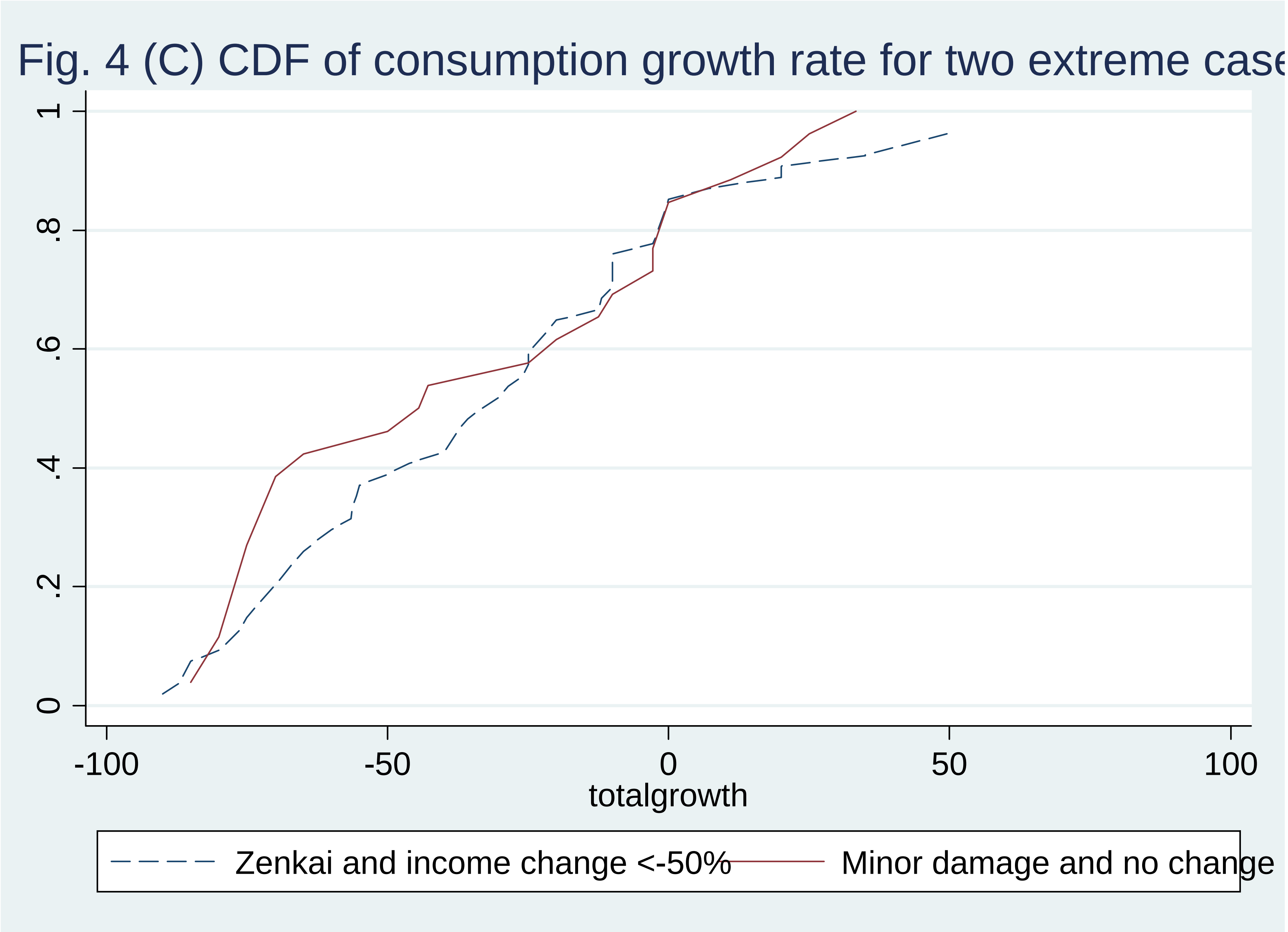


Fig. 4 (C) CDF of consumption growth rate for two extreme case
0
.2
.4
.6
.8
1
-100
-50
0
50
100
totalgrowth
Zenkai and income change <-50%
Minor damage and no change

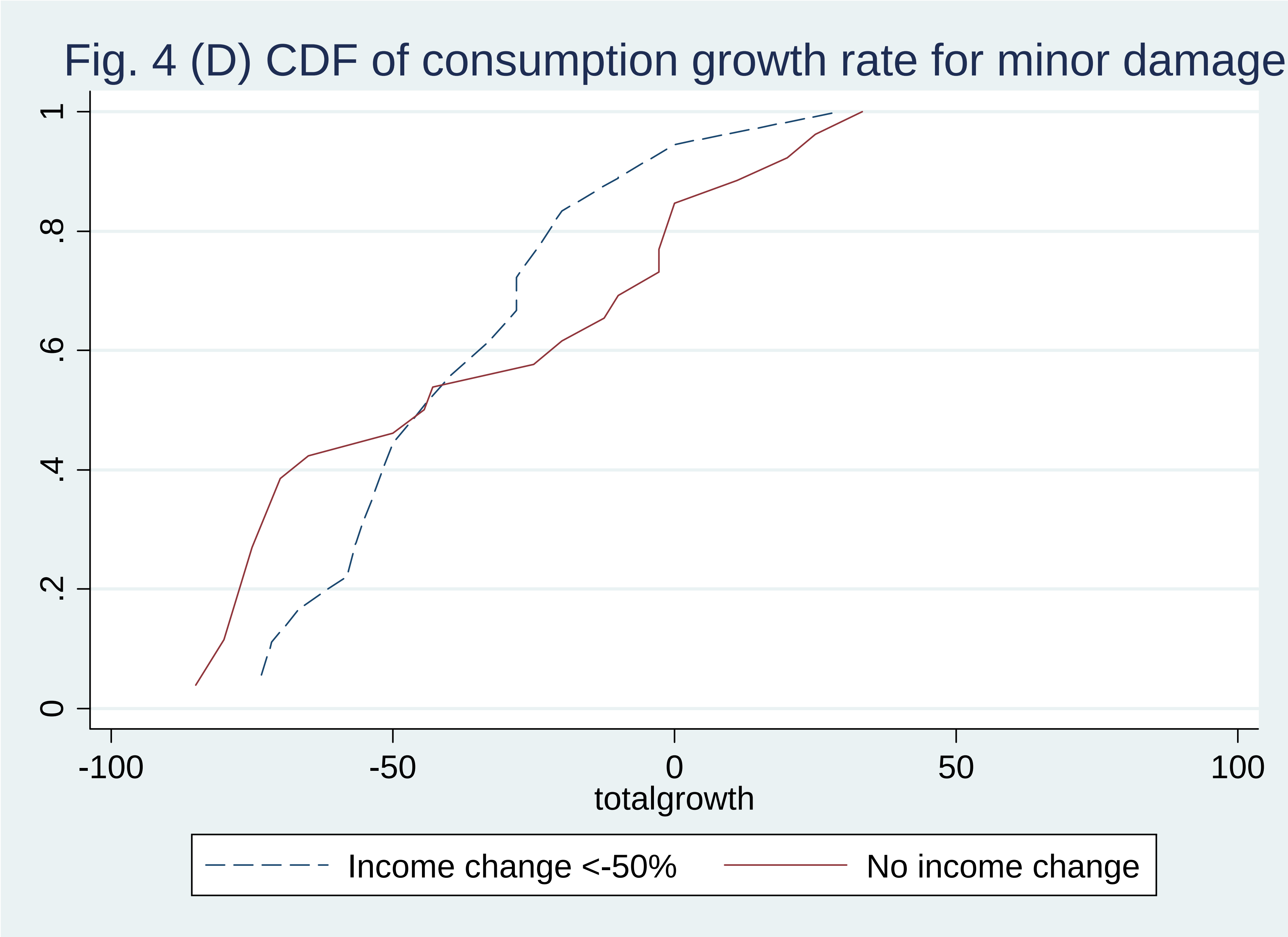


Fig. 4 (D) CDF of consumption growth rate for minor damage
0
.2
.4
.6
.8
1
-100
-50
0
50
100
totalgrowth
Income change <-50%
No income change

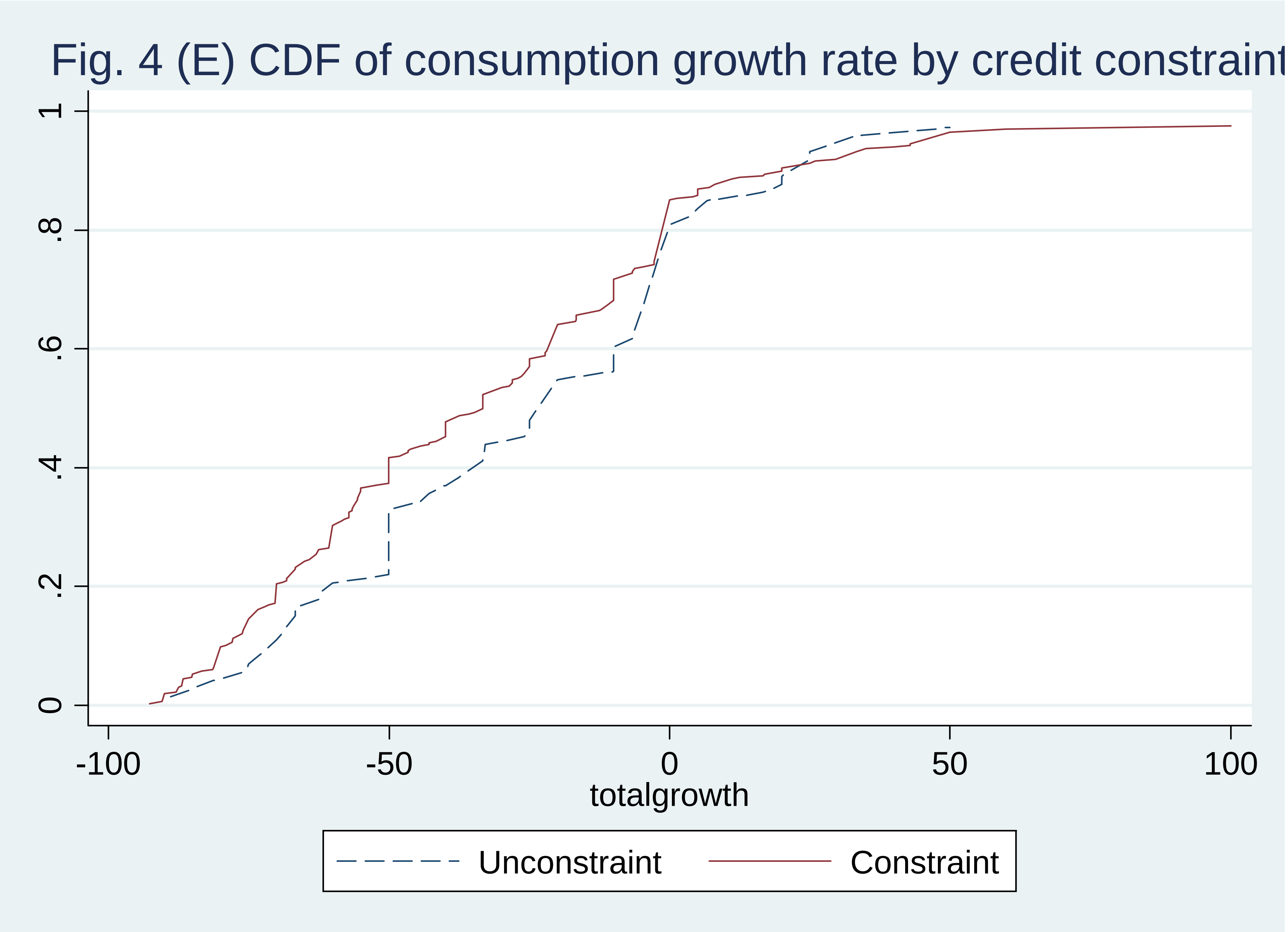


Fig. 4 (E) CDF of consumption growth rate by credit constraint
0
.2
.4
.6
.8
1
-100
-50
0
50
100
totalgrowth
Unconstraint
Constraint

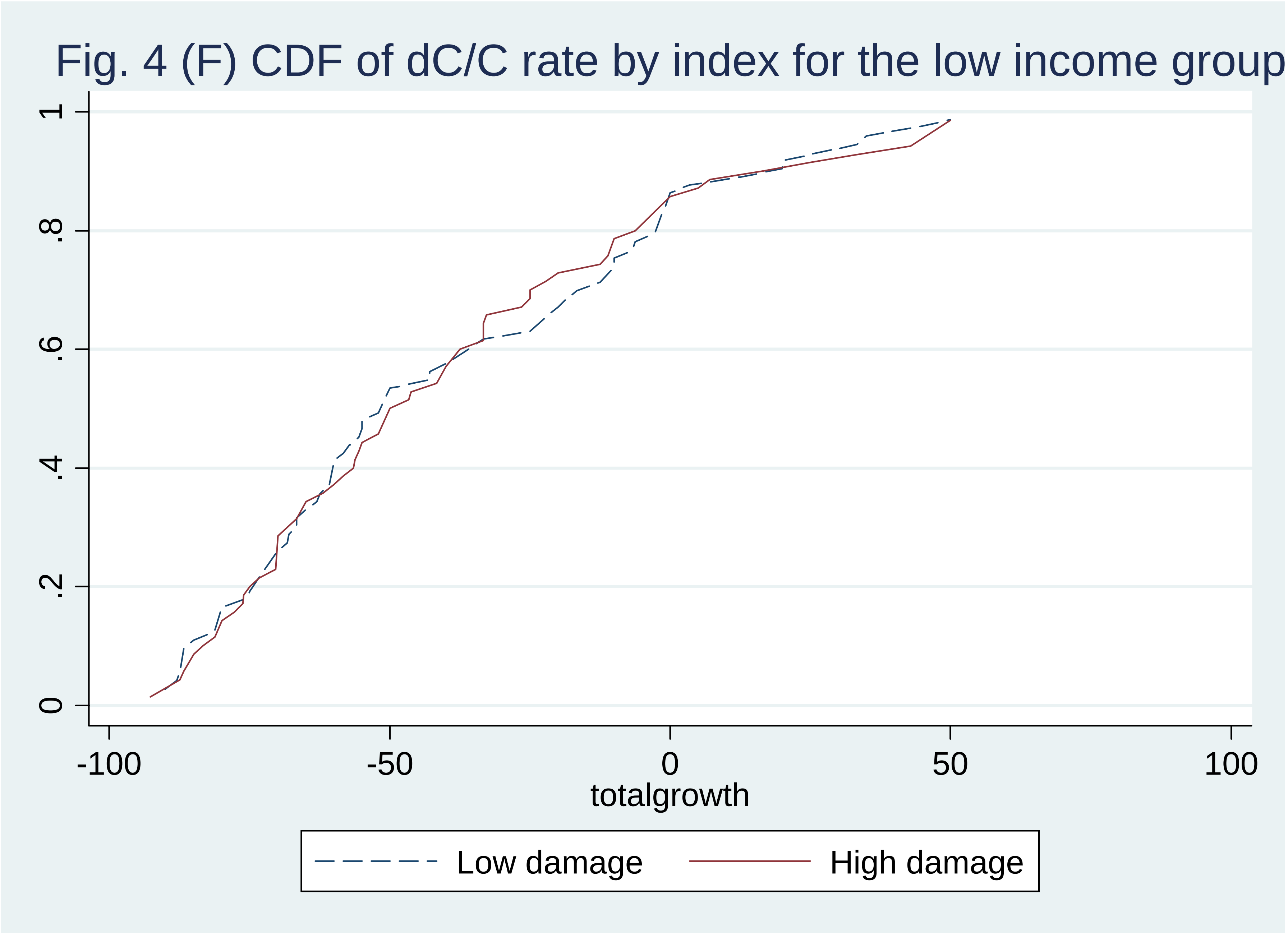


Fig. 4 (F) CDF of dC/C rate by index for the low income group
0
.2
.4
.6
.8
1
-100
-50
0
50
100
totalgrowth
Low damage
High damage

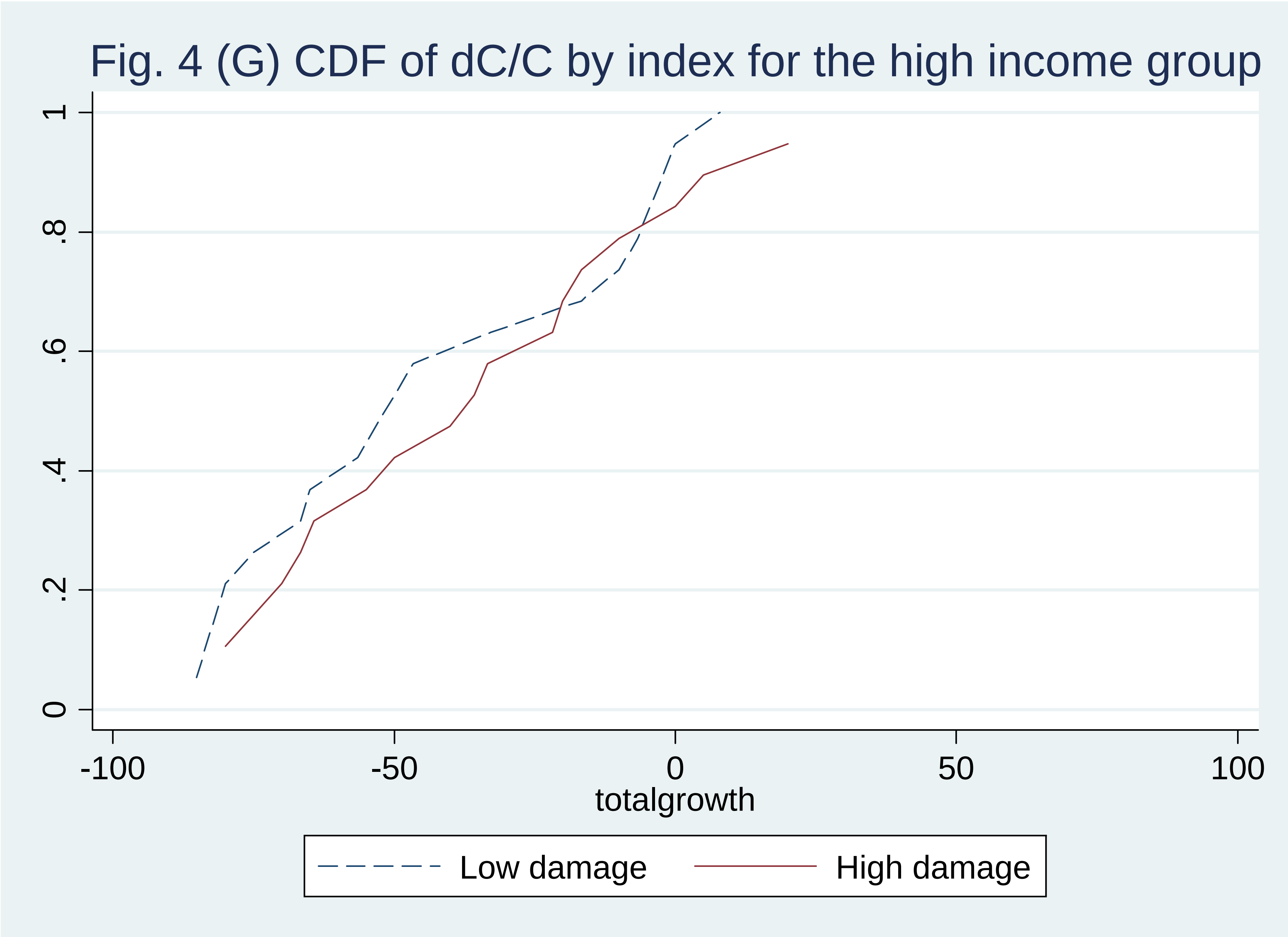


Fig. 4 (G) CDF of dC/C by index for the high income group
0
.2
.4
.6
.8
1
-100
-50
0
50
100
totalgrowth
Low damage
High damage

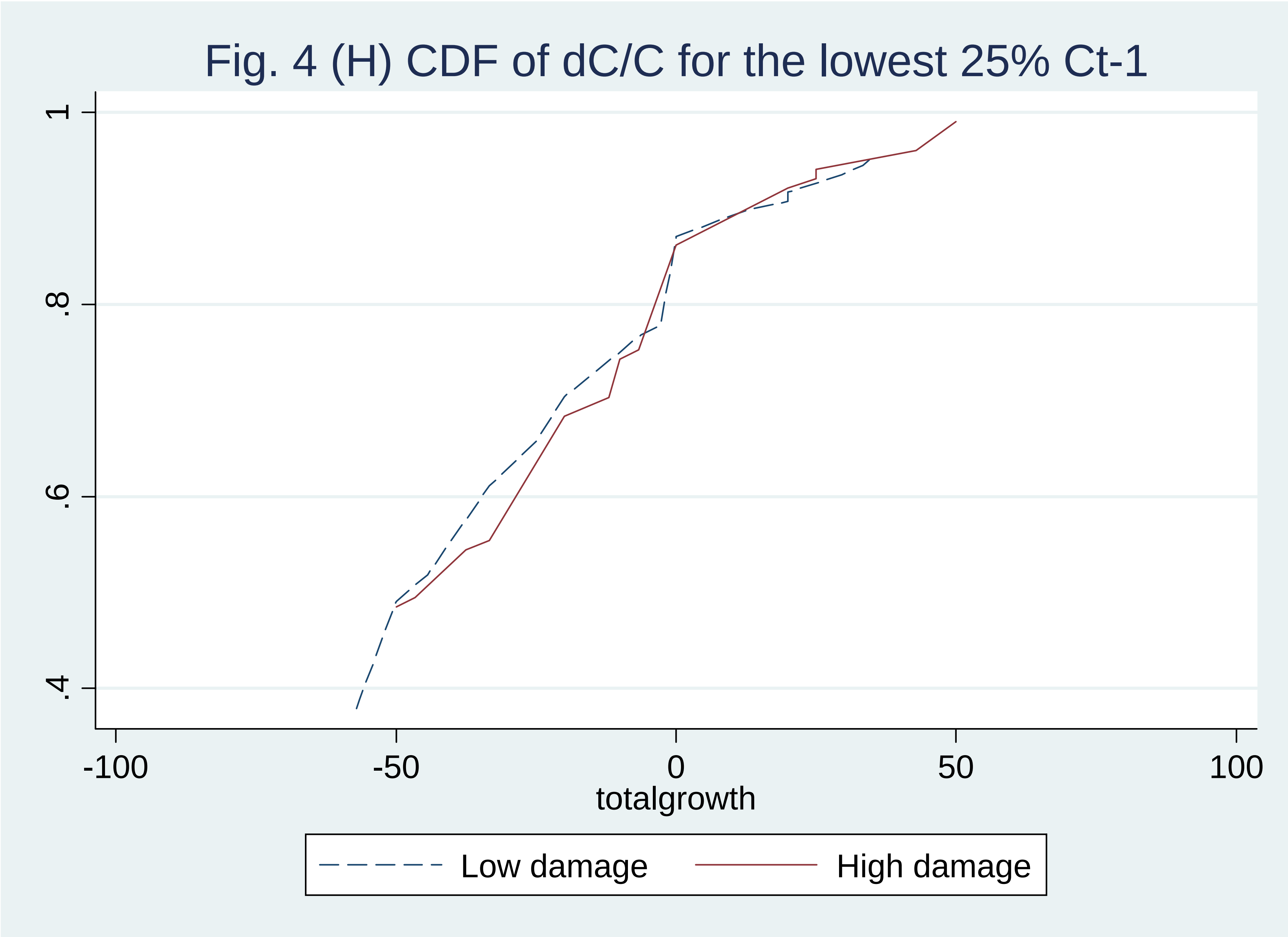


Fig. 4 (H) CDF of dC/C for the lowest 25% Ct-1
1
.8
.6
.4
-100
-50
0
50
100
totalgrowth
Low damage
High damage

Figure 5a. Private Transfers
Shelter Residents vs Co-Residents (unit: 10,000 Yen)

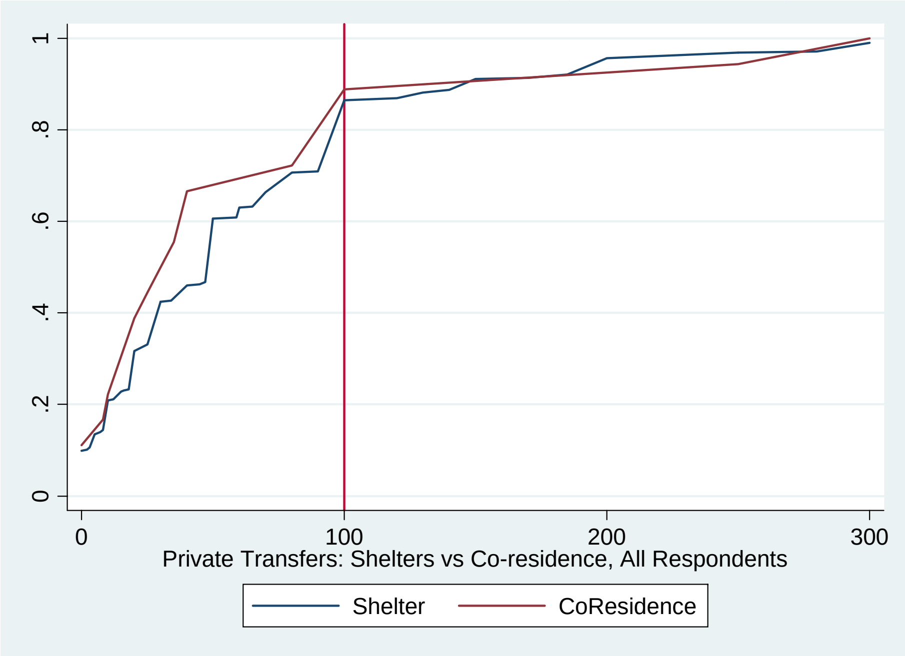


Figure 5b. CDF of Private Transfers:
Collapsed (Zenkai) vs Half-Collapsed (Hankai)
Homeowners in Shelters

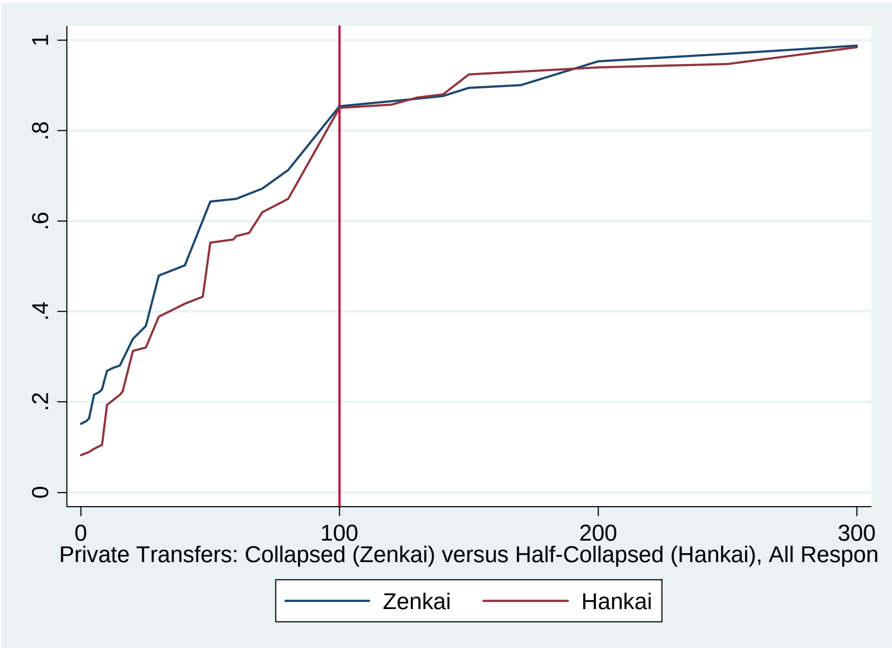


Figure 5c. Private Transfers:
Half-Collapsed (Hankai) vs Minor Damages (Ichibu)
Homeowners in Shelters

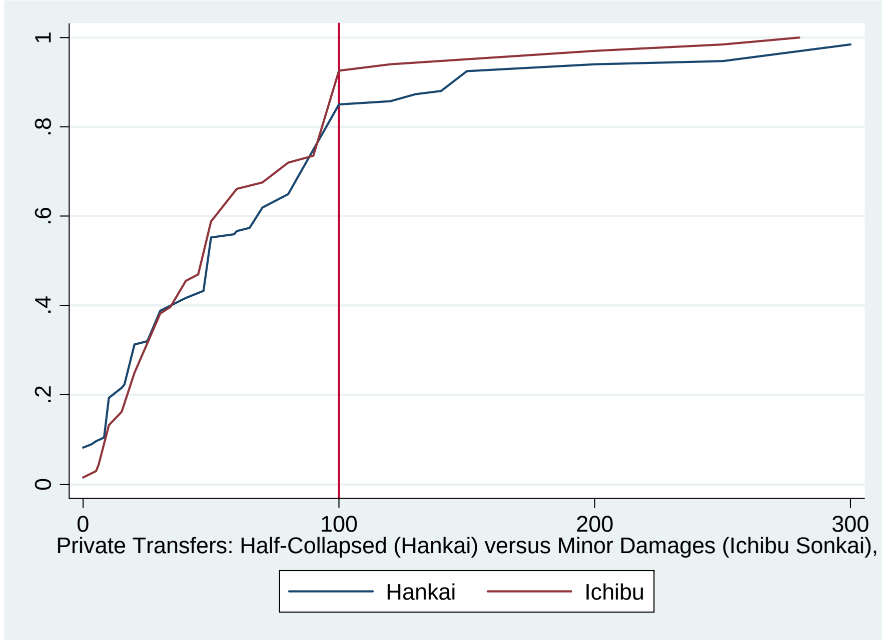


Figure 6.
Earthquake Insurance Indemnity Payments

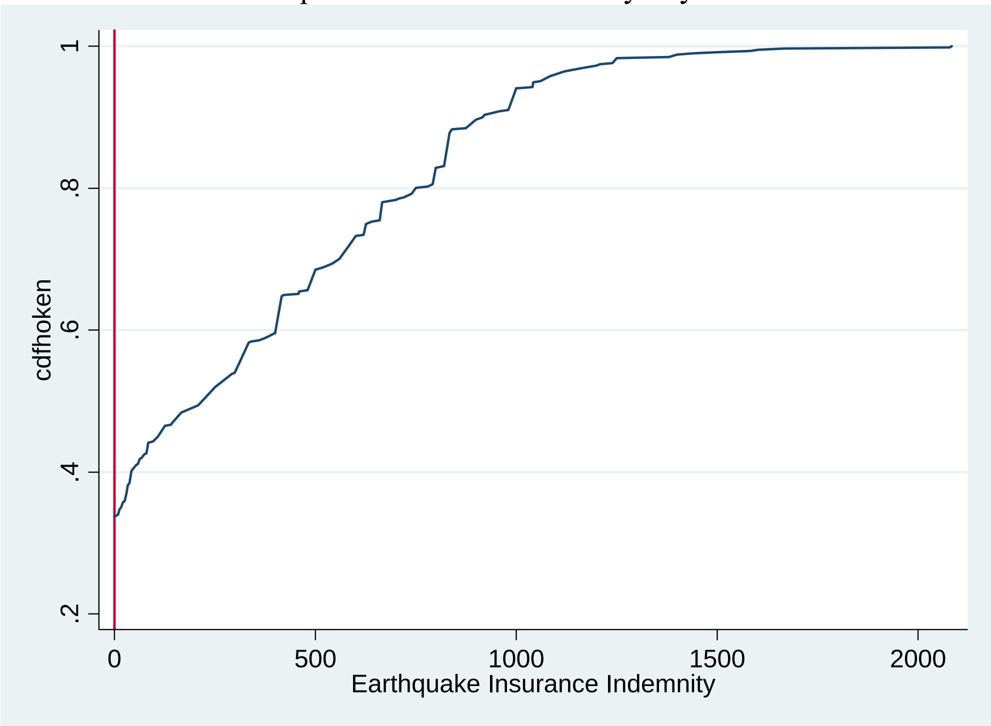


Figure7.
Total Gross Amount of All Damages

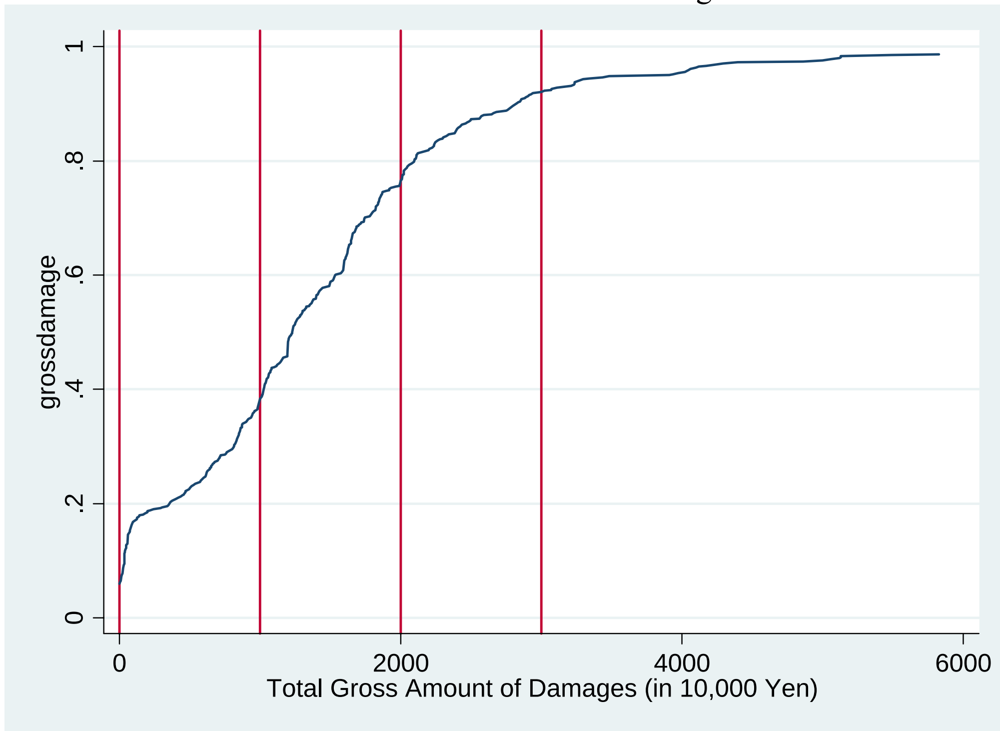


Figure 8 Gross and Net Damages: All House Owners in Shelter

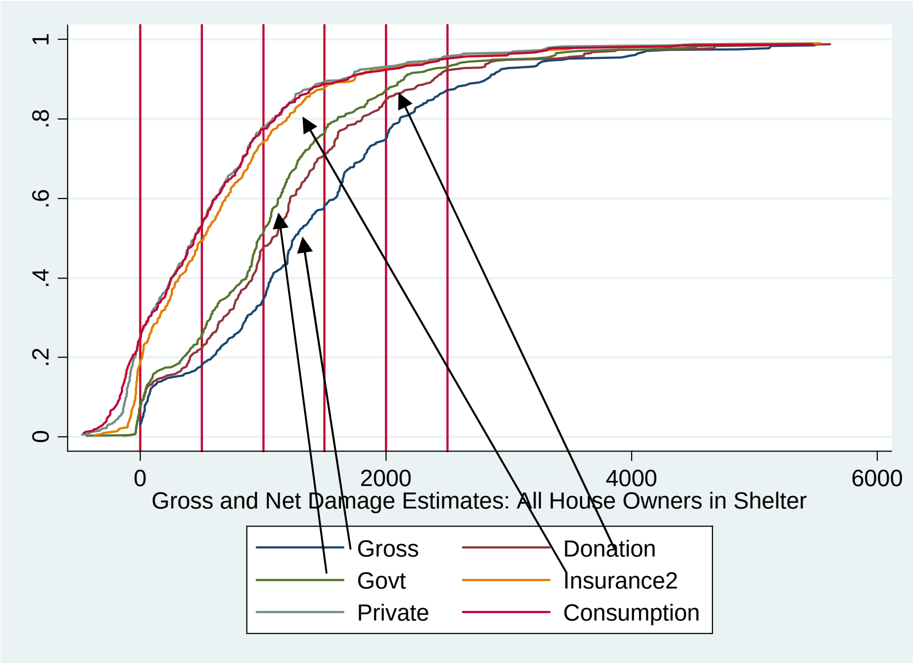


Figure 10. Half-Collapsed House Owners

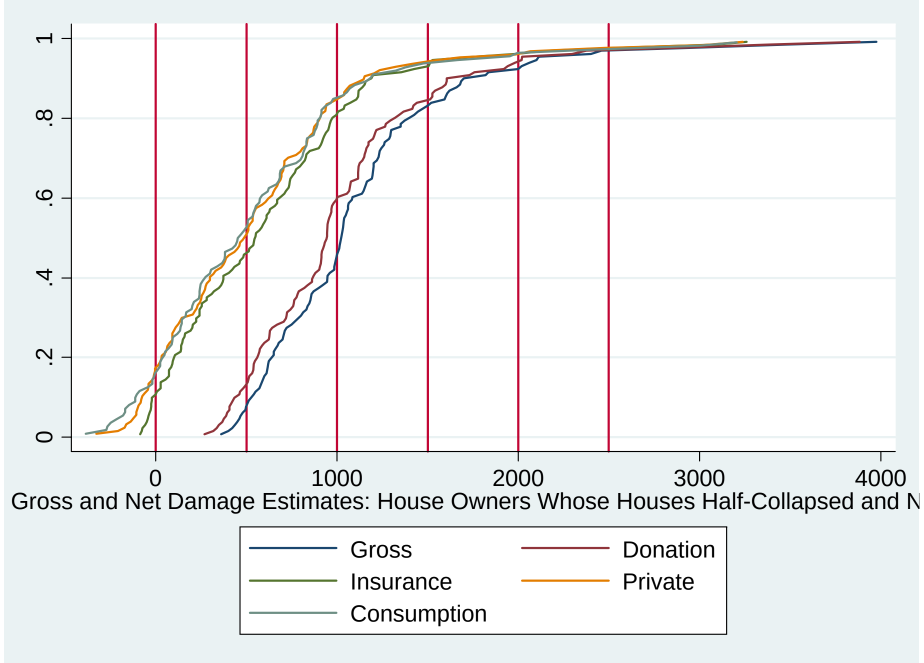


Figure 9 Collapsed House Owners

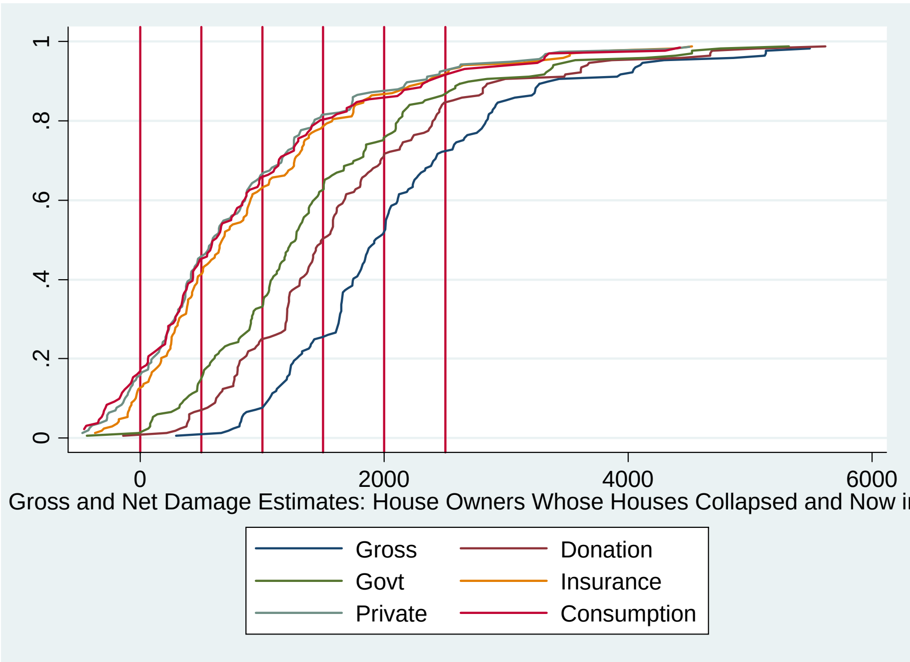


Figure 11. Minor Damage Owners

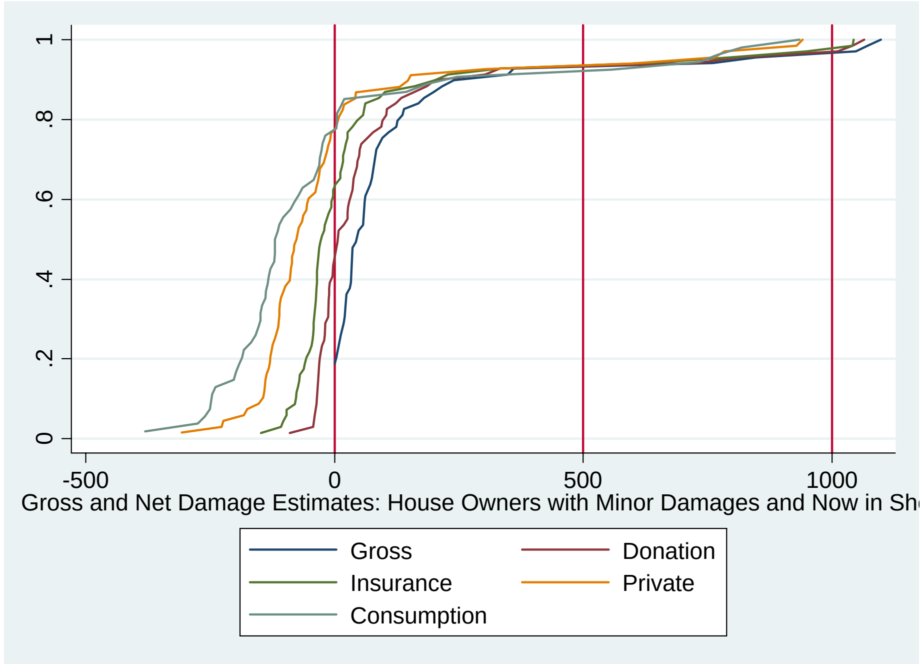


Figure 12. Gross and Net Damages:
Those House Owners in Shelter Who Reported
the Importance of Self-Insurance (Dissaving)

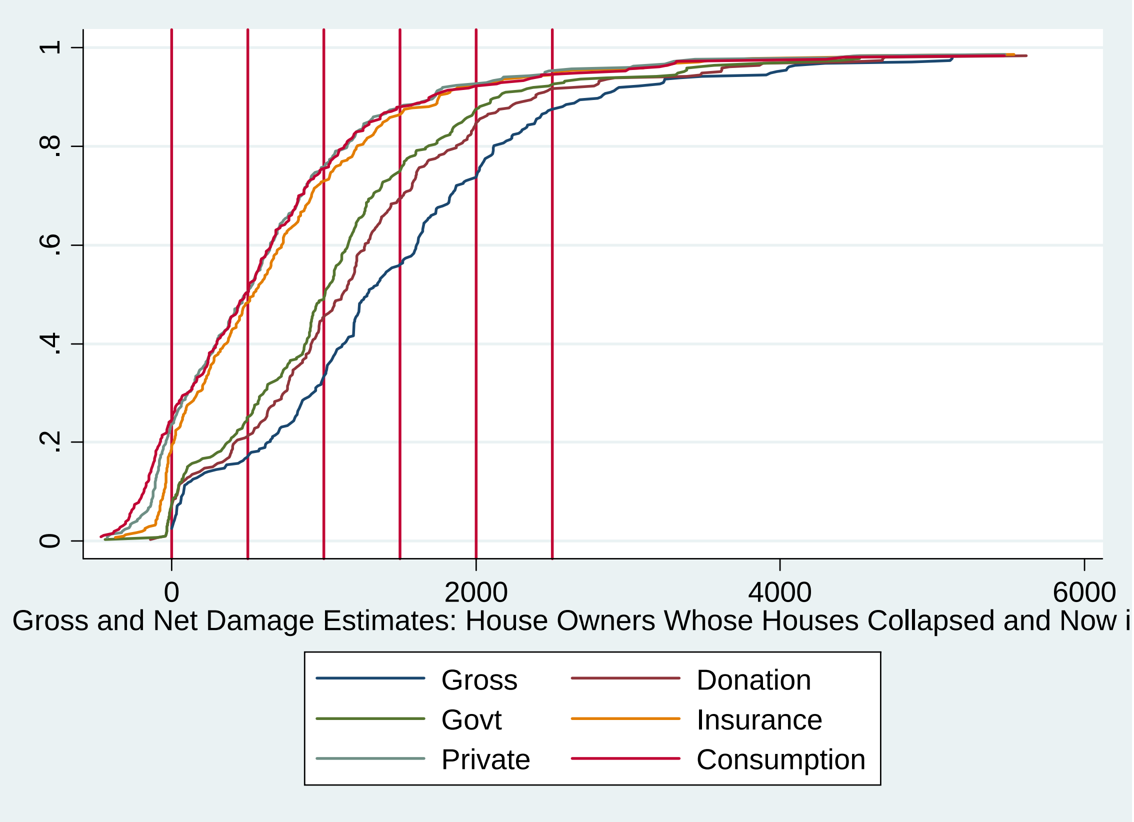


Figure 13. Gross and Net Damages:
Those House Owners in Shelter Who Reported
the Unimportance of Self-Insurance (Dissaving)

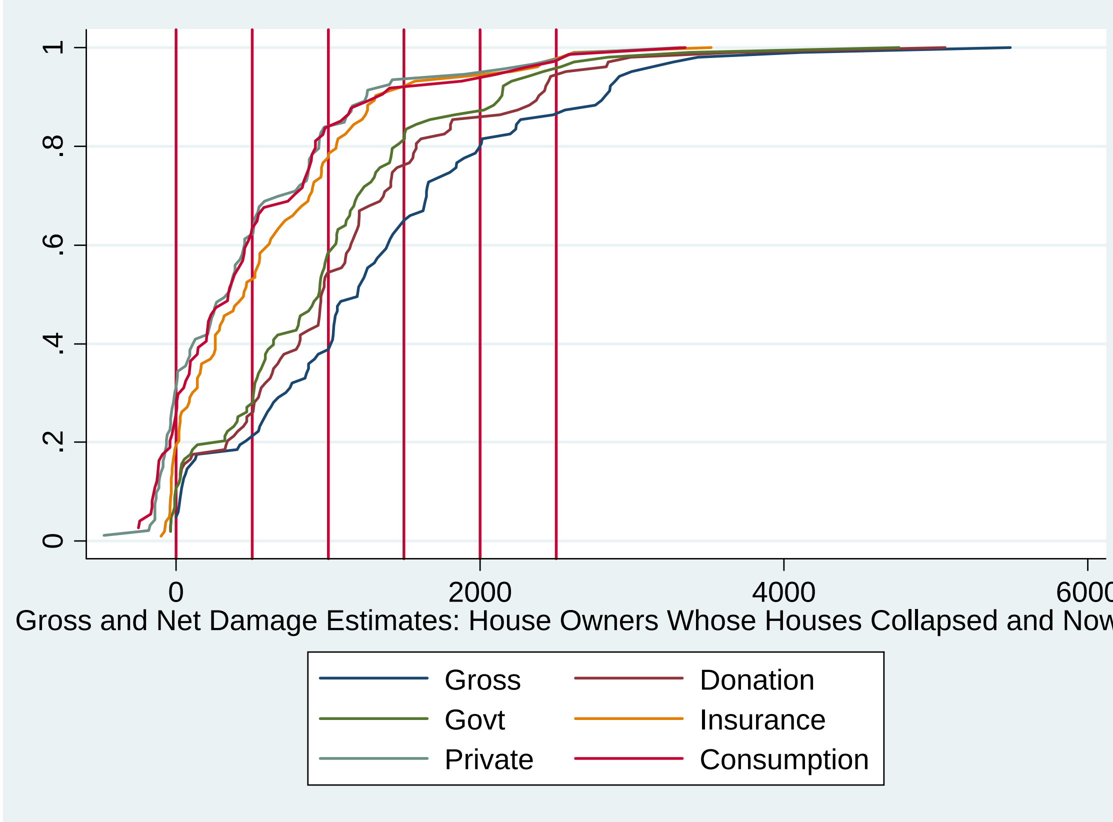


Figure 14. Gross and Net Damages:
Those House Owners in Shelter Who Are Credit Constrained
and Reported the Unimportance of Self-Insurance (Dissaving)