Tsukuba Economics Working Papers
No. 2009-002

Forest and Sea as Insurance among Fijians

by

Yoshito Takasaki

March 2009

UNIVERSITY OF TSUKUBA
Department of Economics
1-1-1 Tennodai
Tsukuba, Ibaraki 305-8571
JAPAN

Forest and Sea as Insurance among Fijians

Yoshito Takasaki

Graduate School of Humanities and Social Sciences
University of Tsukuba
1-1-1 Tennodai, Tsukuba
Ibaraki 305-8571 Japan
Tel./fax.: +81 29 853 6280
E-mail address: takasaki@sk.tsukuba.ac.jp

January 8, 2009

Abstract
This paper examines how forest and marine resources serve as insurance against a tropical cyclone using original household data gathered in rural Fiji. The fixed-effects estimator for a censored dependent variable controls for unobservable household heterogeneity that can cause bias. I propose a simple empirical strategy, which can be widely applied, to test whether a household intensifies labor activity to earn extra income to be shared under private risk-sharing arrangements. I find that while households abandon forest product gathering right after the cyclone, value-added handicrafts made of some forest products by women serve as self-insurance against crop damage after the emergency period and this is especially so among female-headed households. Fijians intensify fishing to augment mutual insurance for the recovery from village facility damage and housing damages experienced by others. I discuss how this distinct pattern emerges as private adjustments to cyclone relief delivered to the region.

Acknowledgements
I wish to thank my field team – Jonati Torocake, Viliame Manavure, Viliame Lomaloma, Maria Torocake, and Anaseini Savuiwasa – for their advice, enthusiasm, and exceptional efforts on behalf of this project. Special thanks are owed also to the Fijians of the region who so willingly participated in the survey. Xiaowen Mo undertook the laborious task of data entry and cleaning. This paper has benefited from suggestions from Oliver Coomes. This research has been made possible through support provided by Sumitomo Foundation, Japan Society for the Promotion of Science, and Ministry of Education, Culture, Sports, Science and Technology in Japan. Any errors of interpretation are solely the responsibility of the author.

Forest and Sea as Insurance among Fijians

1. Introduction

Do the poor use local natural resources to cope with adverse shocks? This question of 'natural insurance' has received explicit attention among economists since 1980s (e.g., Jodha, 1986) and systematic works based on micro survey data recently started to provide supportive evidence (Pattanayak and Sills, 2001; Takasaki *et al.*, 2004; Fisher and Shively, 2005; McSweeney, 2005). Recent theoretical studies highlight advantages of commons as insurance: individual returns to resource use vary little across households in comparison to asset-dependent activities like farming and the former is often uncorrelated with shocks on the latter. For example, Baland and Francois (2005) demonstrate that even if the resource is equitably privatized, commons can have better insurance properties than insurance markets in the presence of information and enforcement problems. Delacote (2007) shows how the insurance role of tropical forests is related to deforestation. The natural insurance concept has led to increasing recognition that environmental conservation is important for the poor not only for income earnings but also for safety net.

Using original survey data gathered in Fiji, this paper examines *how* households use natural insurance against a tropical cyclone. This question is of critical importance for successful resource management and safety-net policy in small island states whose environments are highly vulnerable and economies heavily rely on foreign aid (Bertram, 1986). Some researchers have criticized the deterioration of islanders' indigenous mechanisms in coping with cyclones due to their increasing dependency on emergency aid (e.g., Campbell, 1984). Contrary to extensive anthropological studies, economic studies based on household survey data are almost nonexistent in the Pacific region.

The paper makes four contributions to the literature. First, distinct from previous studies on natural insurance based on cross-section data or random-effects models, I follow the theoretical framework of ex post labor supply (Kochar, 1999; Rose, 2001) and employ fixed-effects estimators based on panel data. I show that to obtain unbiased estimates of a coping response to idiosyncratic shocks which are partially insured by private risk sharing, unobservable household heterogeneity needs to be controlled for.

Second, I address the role of ex post labor supply not only as self-insurance but also in mutual insurance (Rosenzweig, 2001 emphasizes the importance of the connection of these two). I propose an empirical strategy to test whether a household intensifies its labor activity against others' shocks to augment resources to be shared. On the other hand, recent studies shed lights on risk-sharing networks (e.g., Fafchamps and Lund, 2003). I examine how ex post labor supply is connected with risk sharing not only within a village but also within a kin group in the village in the kin-based Fijian society.

Third, I compare the roles of natural insurance between forest and marine resources. Most previous works focus on wood and non-timber forest products (NTFPs). As an exception, Takasaki *et al.* (2004) show that Amazonian peasants more commonly resort to riverine fishing than NTFP gathering (and hunting) in response to crop loss caused by floods. The paper examines both the collection of NTFPs and the sales of handicrafts made of NTFPs by women. While the importance of NTFPs among poor women is frequently emphasized (e.g., Agarwal, 1990), the insurance role of value-added NTFP products often produced by women has received limited attention in the literature.

Fourth, I examine how distinctively natural insurance works against different shocks caused by the cyclone – housing, crop, and village facility damages. Distinct availabilities of cyclone relief corresponding to these shocks in the region make the relative importance of risk sharing against them also distinct. When pre-disaster information was collected retrospectively as in other post-disaster surveys (e.g., Morris *et al.*, 2002), with the uniform and easily identified timing of the cyclone, respondents could make a clear temporal separation between ex ante and ex post periods. I examine how their coping behaviors evolve after the disaster, an unexplored question in the literature.

The major findings of the paper can be summarized as follows. Distinct from previous findings in forest-rich regions and despite rich marine resources in the Pacific, Fijians abandon NTFP gathering in the emergency period but augment handicraft selling, not fishing, as self-insurance against crop damage, not housing or village damage, after the emergency period. Female-headed households do so more strongly than male-headed. Fijians intensify fishing against village damage and housing damages experienced by others in the same village and kin group. The way they do so depends on the relative severity of own and others' housing damages in the multilayered risk-sharing arrangements among villagers and kin-group members.

The rest of the paper is organized as follows. Section 2 describes the study area, labor activities, and the cyclone. Section 3 discusses the econometric specification followed by the estimation results in Section 4. The last section concludes.

2. Study area, labor activities, and cyclone

On January 14, 2003, Cyclone Ami swept over the northern and eastern parts of the Fiji Islands. My post-cyclone survey covered nine native Fijian villages on the coast.[1]

---

[1] The nine villages were intentionally chosen to cover distinct environmental and economic conditions. Six and three villages, respectively, are located on Vanua Levu and Taveuni Islands, the second and third largest islands in the country which significantly

In each village, all households were stratified by the smallest kin group unit defined below and the combination of their leadership status and major asset holdings (like shop), and in each stratum, households were randomly sampled (n=374). Between late August and early November, 2003, one visit to each household in the sample was made and the interview asked about its production, income, assets, demographics, cyclone damage, and relief (neither consumption nor labor transfer data were collected). Pre-disaster information was collected retrospectively. Respondents were asked about the production of major crops and the catch of fish in the past one month and then monthly production a year before – i.e., before the cyclone – in comparison to the latest figures. NTFP gathering, handicraft production, and relief received in each month over the past one year were also recorded. Using these two data sets, respectively, I constructed two-period panel of pre-cyclone and post-cyclone periods and four-period panel of pre-cyclone period 1 (October-December 2002) and post-cyclone periods 2-4 (January-March, April-June, and July-September 2003) whose descriptive statistics are shown in Tables 1 and 2. Table 1 also reports household characteristics a year before the interview as well as cyclone damages and both tables compare male- and female headed households. Potential measurement errors are discussed in the next section. The paper analyzes 332 households with complete data (since kin-group means are used as explanatory variables, all kin groups consisting of one household in the sample are dropped).

The hierarchical kin structure in Fiji is well known. The bottom is extended family, *tokatoka*, followed by sub-clan, *mataqali*, clan, *yavusa*, and tribe, *vanua*. All

---

lag behind the first largest island Viti Levu where the state capital, two international airports, and most tourism businesses are situated. Fiji is divided almost equally into native Fijians and Indo-Fijians. This study focuses on the former.

native Fijians belong to one tokatoka which belongs to one mataqlai, and so forth (Ravuvu, 1983). While vanua extends over several villages, yavusa, mataqali, and tokatoka are often formed within a village. The sample includes 15 yavusa, 36 mataqali, and 49 tokatoka and their average group sizes are 33, 15, and 10 households, respectively. While all nine villages contain more than one mataqali, seven consist of only one yavusa, i.e., clan and village coincide with each other. While two vanua range across two villages (there are seven vanua in the sample), there is no across-villages overlap of yavusa. Most ritual activities like funeral, wedding, and traditional meetings are organized by mataqali and yavusa and occasional large meetings are held by vanua. Land and sea tenures are determined by kin groups. Rural land is communally owned by mataqali, privately used, and is not allowed to be sold by law (communal land consists of about 83% of total land in the country). Customary rights for coastal fishing are held by vanua or several yavusa often consisting of several villages. The sample includes seven customary fishing areas – they do not match with seven vanua – in some of which fishing regulations like the ban of Sunday fishing and gill nets exist.

Almost all households in the sample employ traditional farming practices (using no mechanized equipment or animal traction and limited purchased inputs) to mainly produce taro, cassava, coconut, and kava plant (a pepper plant, locally known as *yaqona*, used to make a local beverage kava which is a dominant symbol in Fijian culture, Turner, 1986). None of these crops are seasonal. Most households conduct subsistence fishing using lines and hooks, simple spear guns, or rudimentary nets, and more commercially-oriented fishermen use boats and engine along with more valuable nets. Fishing is less seasonal than forest resource use discussed next.[2] The cropping and fishing incomes a year before the interview count for 54% and 29%, respectively, of total income.

Many dwellers, both men and women, gather forest products like wild fruits for consumption and cash earnings. Only women make handicrafts from indigenous plants to be used as ceremonial gifts and some craftswomen sell their produce in the local markets and small resort hotels for tourists.[3] These NTFPs on communal land are essentially open access to all villagers and forest extraction is unregulated. In period 1 – before the cyclone – 58% and 12% households, respectively, in six out of nine villages (n=223) gathered NTFPs and sold handicrafts but their contributions to total income were negligible (in the remaining three villages these two activities were almost nonexistent).

12% households are headed by female. The female headed have a weaker farming capacity – they are older, are less educated, and hold smaller land – than the male headed, earning much lower crop income before the cyclone; contrarily, the female headed earned greater fishing income (the gendered division of labor is weak in farming and fishing and female fishers are known to be active in Fiji, Chapman, 1987) and the gender-disparity in total income was not large. While the female headed more commonly sold handicrafts in period 1, there is no across-gender difference in sales and NTFP gathering.

Differing from other islands in the country, the study area is less prone to be hit by cyclones and Ami was the only cyclone in the season – it was totally unpredicted by

---

[2] In each village the seasonality of major forest and marine products were asked. 91%, 17%, and 77% of NTFPs (excluding firewood), finfish species, and other marine products, respectively, are seasonal. The contribution of other marine products to income is much smaller than finfish.

[3] The three most important handicrafts are famous Fijian mat *voivoi* made of screw pine, *Pandanus thurstonii*, finer mat *kuta* made of soft sedge, *Eleocharis dulcis*, and bark cloth *tapa* made of paper mulberry, *Broussnetia papyrifera*.

local residents. All nine sample villages were damaged and relief delivery by NGOs and the government started only in March.[4] According to the subjective measure of respondents, the cyclone damaged 53% residents' houses – 8% completely destroyed and 45% partially damaged. 37% of households with housing damaged became refugees. They stayed in others' residence in the same village – permanent migration was nonexistent – and about half and two thirds of them, respectively, lived with households in the same tokatoka and mataqali. Clearly, kin groups served as a risk-sharing group.

Labor sharing for emergency housing repair was intensively undertaken among males, and as more and more dwellings were repaired, refuges became uncommon. Public support for housing rehabilitation was limited to primitive tarpaulins (to be used as emergency shelter and for temporary housing repair) and their provision was scarce – only 12% households were recipients (by June). More than one year after the cyclone the government started to provision construction materials. Hence, how victims could rehabilitate their dwellings depends on how much construction materials and labor support they could secure in their own ways. At the time of interviews, refugees were almost nonexistent, 16 victims built a new house, and 60% damaged dwellings (including separate kitchen, shower, and toilet units) were repaired – 65% among the male headed vs. 43% among the female headed. In the village-level public rehabilitation programs, communal labor – mostly male – also played a main role and at the time of interviews most village facilities were not fully rehabilitated due to lack of construction materials.

---

[4] The total cyclone damage across the country (mostly in Vanua Levu and Taveuni) is estimated at F$104 million, of which dwelling damage is F$22 million and crop damage is F$40 million (F$1 = US$.60) (National Disaster Management Office, 2003). Fourteen people were killed. In the sample villages no casualties and very limited injuries and illnesses caused by the cyclone were reported.

88% households experienced crop damage. I calculated the value of damaged crops based on the quantity damaged for each major crop reported by respondents. The mean value of damaged crops was about 34 Fiji dollar per adult equivalent (F$1 = US$.60), or equivalently 57% mean monthly pre-cyclone crop income. Emergency food aid was the largest relief in the region (the total cost of food ration was 20 times that of tarpaulins in the country, National Disaster Management Office, 2003). By April almost all households got some food aid and in each of the three post-cyclone periods they received about 10 days of food per month on average (provisions continued until September).[5] That is, an average household could rely on aid to cover about one third of its food consumption. Compared to crop damage, this is a huge injection. Based on the government estimate of the cost of food ration (F$1.73 per person per day, National Disaster Management Office, 2003), the value of 90-days food ration for nine months, F$156 per capita, is 4.5 times average crop damage per adult equivalent.

Distinct from housing and village rehabilitations, households individually rehabilitated cropping by collecting harvestable damaged crops, cleaning fields, and planting seeds. People planted fast-growing crops (like sweet potato) after their seeds were provisioned as part of relief and the harvest already started at the time of interviews. Mean crop income was still lower than the pre-cyclone level by 42%. While no gender-disparity exists in housing damages, the female headed experienced *proportionally*

[5] Because the monetary value of food aid received was difficult for respondents to answer, interviewers asked the quantity measured in days it would have taken to consume in *normal* periods (not actual duration of consumption). Four villages on Vanua Levu interviewed from late August through mid-September, earlier than the other five, received (almost) no food aid in July or later, but they might receive some after the interviews. Table 2 shows food aid in period 4 in the remaining five villages. All four villages interviewed late are included in the six main handicraft villages.

greater crop damage than the male headed – 54% vs. 101% of monthly pre-cyclone crop income. Nevertheless, the relative gender-disparity in crop income did not increase over the past one year, indicating that the female headed more rehabilitated cropping than the male headed.

In period 2 right after the cyclone, households abandoned NTFP gathering. Most NTFPs are seasonal but seasonality only partly explains this pattern (see note 2). The deteriorated access to gathering sites due to downed trees and debris precluded households from doing this activity in some locations but not all. The most likely reason for this abandonment is to free labor for other coping activities under emergency. Indeed, gathering recovered in periods 3 and 4 but participation was still much lower than the pre-cyclone level. Participation in and revenues from handicraft selling also did not change much in period 2 but greatly increased later. This pattern matches with the recovery of tourists' demand. Main handicraft NTFPs are not seasonal.

The female headed more commonly participated in handicraft selling and sold more than the male headed in period 4. Among the female headed, the sales amount was 16 times that in period 1 and the income share of handicrafts reached 19% in the whole female head sample. On the other hand, in comparison to the pre-cyclone level fishing income significantly decreased especially among the female headed and as a result its gender-disparity disappeared. Damages on fishing capital which could cause this pattern were not common. Households, especially the female headed, shifted labor from risky fishing to less risky handicraft selling; they did not intensify NTFP gathering probably because of its lower returns to labor (with lack of time allocation information, I cannot compare returns to labor across activities).

These findings give initial evidence that handicraft selling in periods 3 and 4 – especially among the female headed in period 4 – served as self-insurance but NTFP gathering and fishing did not. Other potential coping activities than private transfers and informal loans must have played minor roles. Casual wage labor, a focus of previous works on ex post labor supply, was very rare and its contribution to total income was negligible. Livestock selling contributed little to income earnings. The disposition of fishing capital and the transfer of usufruct of land to smooth consumption after the cyclone was nonexistent. Indeed, fishing capital and land holdings did not change in the past one year almost at all. Formal credits and insurance were nonexistent.

3. Econometric specification

Numerous works have tested the full-risk sharing hypothesis using the equation

$$c_{it} = \alpha_0 + \alpha_1 z_{it} + \alpha_2 W_{vt} + u_i + v_{it} \text{ ,}$$

where i, v, and t stand for household, village, and time, respectively, c_{it} is household consumption, z_{it} and W_{vt}, respectively, are household- and village-level adverse shocks, u_i is unobservable household heterogeneity, and e_{it} is a time-variant error term which is individually and independently distributed (e.g., Townsend, 1994). The null hypothesis of full risk sharing among households is that individual consumption is unaltered by idiosyncratic shock as they efficiently share available resources which are only altered by covariate shock, i.e., $\alpha_1 = 0$ and $\alpha_3 < 0$. As unobservable welfare weights used in the risk sharing are correlated with idiosyncratic shock, to eliminate u_i using fixed-effects models is needed to obtain unbiased estimates. The full-risk sharing model has been extended to examine risk sharing within other group than village such as cast (Morduch, 2005) and household network (Fafchamps and Lund, 2003; De Weerdt and Dercon, 2006):

$$c_{it} = \alpha_0 + \alpha_1 z_{it} + \alpha_2 W_{vt} + \alpha_3 w_{gt} + u_i + v_{it} ,$$

where w_{gt} is a covariate shock in group *g*. If risk is shared at the village level not group, the addition of the group shock is redundant as the village shock is already controlled for; its significant impact on consumption means that risk is shared among group members.

Rose (2001) offers a theoretical framework for household labor supply decisions in response to a covariate shock on own farm production (regional rainfall). Adding an idiosyncratic shock to her model gives rise to the ex post labor supply equation

$$L = L(z, W, X, V),$$

where *z* and *W*, respectively, are idiosyncratic and covariate shocks as before, and *X* and *V*, respectively, are household- and village-level factors which affect returns to labor like productive assets and market prices. The standard income effect suggests that with greater adverse shocks, income is lower and the household will increase labor supply to smooth income (Rose, 2001): that is, β_1, $\beta_2 > 0$ in the estimating equation

$$L_{it} = \beta_0 + \beta_1 z_{it} + \beta_2 W_{vt} + \beta_4 X_{it} + \beta_5 V_{vt} + u_i + e_{it} . \quad (1)$$

As in the full-risk sharing model, the model (1) can be extended to

$$L_{it} = \beta_0 + \beta_1 z_{it} + \beta_2 W_{vt} + \beta_3 w_{gt} + \beta_4 X_{it} + \beta_5 V_{vt} + u_i + e_{it} . \quad (2)$$

In the case of sub-groups within the village, impacts of the covariate shock measured at the village level in (1) are decomposed into those at the group and village levels in (2).

Ex post labor supply and risk sharing are related with each other. On one hand, risk sharing lowers the demand for income smoothing through labor activities. With full risk sharing ($\alpha_1 = 0$), labor supply is unresponsive to idiosyncratic shock ($\beta_1 = 0$) while uninsured covariate shock still matters. On the other hand, additional labor income augments resources to be shared. As the full-risk sharing model captures consumption smoothing against idiosyncratic shock *after* households earn ex post labor income, the reduced-form models (1) and (2) capture household labor response to idiosyncratic shock *after* it is weakened by risk sharing. Hence, in the models (1) and (2), unobservable welfare weights used in the risk sharing affect household labor supply decisions and any partly insured idiosyncratic shocks (like illness) are endogenous. Unless researchers focus on covariate shock, they need to control for household heterogeneity u_i using fixed-effects estimators. Random-effects estimates are unbiased on the assumption that ex post labor supply is unrelated with risk sharing, which is too restrictive.

Although to develop a theory combining the household labor supply model and the full risk-sharing model is beyond the scope of the paper, I empirically explore the resource-augmentation effect. Suppose that in the model (1) the idiosyncratic shock is a dummy variable which perfectly distinguishes recipients and donors in the risk-sharing arrangement among villagers, and the village-level covariate shock is measured by the village mean of this dummy (a standard procedure in the literature on risk sharing). I run the reduced-form regressions among households with and without the idiosyncratic shock – recipients and donors – separately maintaining the village-level covariate shock measured in the whole sample. Then, the positive coefficient for the covariate shock in the donor sample shows how much donors augment labor supply against the shocks experienced by others in the same village. To extend this sub-sample analysis to the model (2) with the group mean is analogous.

I examine two idiosyncratic shocks caused by the cyclone, housing damage captured by two dummies, one for partial damage and another for complete damage, and crop damage captured by the value of crop damage per adult equivalent (log). Apart from the aforementioned risk-sharing effect, household crop damage is endogenous because unobservable household and village characteristics such as land quality, farming skills, market conditions, environmental conditions (e.g., resource stock), and institutions (e.g., resource use regulations) affect pre-cyclone cropping decisions which determine crop damage. Housing damage should be much more exogenous. Indeed, households with and without housing damaged do not significantly differ from each other in their pre-cyclone income, asset holdings, and household characteristics (results are not shown), indicating the randomness of housing damage. Housing damage can be related with unobservable initial housing characteristics which might be somewhat correlated with unobservable determinants of labor supply though. In the Fijian panel data, most of these unobservable factors – including pre-cyclone cropping decisions and potential ex ante risk-management behaviors – are fixed effects which can be controlled for by fixed-effects estimators. Although all household-level factors determining production technology like productive assets (X_{it}) are also fixed effects, they may influence household labor responses to the shocks as they alter returns to labor. This issue is examined in the next section.

In all models a time dummy captures common events or trend including seasonality. I consider two specifications for village-level time-variant factors. The first uses village-time dummies which capture all village-level factors including unobservable ones like market prices of various products. The second specification focuses on observable village-level factors – the village means of the three idiosyncratic shocks discussed above, the village mean of food aid per month (log), the proportion of households receiving tarpaulins in the village, and a dummy for damages on main village facilities (school, health center, and church). The relief variables measured in periods 2 and 3 – period 4 is not included for the reason given in note 5 – capture cyclone relief as positive shocks. Relief received by individual households is not included because it is endogenously determined as part of private risk sharing (Dercon and Krishnan, 2005). With only nine villages in the sample, interpretations of estimation results of these village-level variables need caution – better analysis requires a much larger number of villages with richer spatial coverage (ideally including villages with no cyclone damage).

In the model (2) I examine tokatoka and mataqali as a potential risk-sharing group within the village by using the group means of the three idiosyncratic shocks as group-level covariate shocks (as discussed above, yavusa is almost the same as village and most vanua and customary fishing areas are larger than village). With the relatively large numbers of these groups, estimated standard errors are clustered by the groups. The group and village mean estimates should be accurate because on average about 70% households were sampled in each stratum defined by tokatoka.

Household labor response to the mean damage can be either for self-insurance against uninsured covariate shock and for mutual insurance to help others, or both. I conjecture that the sharp contrast between food aid and housing support in their availabilities makes informal risk sharing against housing damage play a much more important role than that against crop damage, and as a result housing damage mostly distinguishes net recipients and donors not only of labor transfer for repairing but also of non-labor sharing to help victims purchase construction materials. Households are divided almost equally into those with and without housing damaged, making such risk sharing possible. Then, the sub-sample analysis for households without housing damaged mainly captures the resource-augmentation effect of ex post labor supply. Importantly, as housing damage is exogenous, potential selection bias is not a concern. The sign of the estimated coefficients for relief should be opposite to damages because public transfer augments resources to be shared as a favorable covariate shock. A positive estimated coefficient for village facility damage indicates that the household augments labor supply to make contributions to the village for rehabilitation.

Non-participation common in NTFP-based activities is an econometric challenge. I employ the trimmed least squares estimator developed by Honoré (1992) to control for unobservable household heterogeneity u_i with a censored dependent variable. Another advantage of this fixed-effects model is that it is robust to heteroskedasticity and non-normality which are other potential sources of bias in random-effects Tobit estimates. This estimator has not been used in previous works on ex post labor supply. I use the first-difference estimator for fishing the participation of which is almost universal.

With lack of time allocation information, I use revenues as a proxy for labor input. Market prices which determine revenues are controlled for by village-time dummies in the first specification (the second specification is discussed below). The fixed-effects estimator controls for any systematic difference between revenues and labor input caused by unobservable skills, fishing capital (which changed little over time), and resource stocks (labor is an effectively unique input for NTFP-based activities). Since the overall significance of estimation results for non-handicraft NTFP gathering is shown to be very weak due to its uncommon participation and small revenues especially after the cyclone, the analysis focuses on handicraft selling as a major form of forest resource use.

To examine the evolution of ex post handicraft responses, I conduct two-period analysis for periods 1 and 2, periods 1 and 3, and periods 1 and 4 separately. In the latter two, labor input in period 3 or 4 is connected with the shocks experienced in period 2 and periods 2 and 3 or periods 2-4 are treated as one post-cyclone period. This is a standard practice in analyzing annual survey data lacking information over time within the year. Two potential problems arise. First, coping behaviors in the previous post-cyclone period(s) correlated with shocks may affect decisions in the subsequent period as an ‘unobservable’ time-variant factor. Second, measurement errors in the timing of production in the original monthly data may be systematically correlated with idiosyncratic shocks. I ran the same regressions using monthly revenues calculated over periods 2 and 3 and periods 2-4 as a dependent variable in the post-cyclone period. Results were very similar to what are presented here. I also employ the 2-period model for fishing, the ex post data of which is at the time of interviews.

Measurement errors in the retrospective data require particular attention. First of all, measurement errors in the two housing damage dummies are minimal because the same categories were used by relief officers for their damage assessments. All village leaders could well recall the total number of damaged houses, that is, the damage status of each dwelling was well known among villagers. On the other hand, measurement errors in the value of crop damage can be considerable and systematic. I repeated all analyses using a dummy for the incidence of crop damage, the errors of which should be minimal. Qualitatively the same results were found (results are not shown).

The evolution of production found in the descriptive statistics may be caused by respondents’ memory loss in early periods. Such memory loss should be small in participation because the very minor activity of NTFP gathering was much less common in periods 3 and 4 than 1. While respondents could well recall the production of handicrafts with significant cultural and social importance (they serve as major ceremonial goods in kava ritual, Turner, 1987), revenues may contain significant measurement errors. While common memory loss is controlled for by the time dummy, the correlation of errors in revenues, especially before the cyclone, with idiosyncratic shocks causes bias. There is no way to control for this potential bias. The positive (negative) correlation – households with larger idiosyncratic shocks tend to report higher (lower) pre-cyclone revenues than the real – causes upward (downward) bias. Thus, unless the correlation is positive and large, estimated positive β_1 is qualitatively robust.

4. Estimation results

The first-difference estimates of determinants of log fishing revenues per adult equivalent per month are reported in Table 3. All results of the model (2) are based on tokatoka. The first four columns show results for the whole sample. When time-variant village-level factors are fully controlled for by village-time dummies (Column 1), households intensify fishing against own crop damage not housing damage. When village-time dummies are replaced with observable village-level variables (Column 2), the estimated coefficients for household-level shocks do not change almost at all, indicating that unobservable village-level time-variant factors do not cause bias. Households strongly adjust fishing to village-level factors. While partial housing damage at the village level exhibits no impacts, households in a village with main facilities damaged and with more houses completely damaged in proportion fish more – the former marginal effect is 25% and the latter is 6.8% for a 1% increase in the proportion of victims in the village (equivalently about 12.6% for an additional victim in an average village with 54 households). Households in a village with more tarpaulins in proportion fish less and the marginal effect in magnitude is about half of that of the complete housing damage. While crop damage at the village level exhibits no significant impact, households in a village with more food aid fish less (8.8% reduction for a 10% increase in food aid). Although these estimates require caution as discussed above, they are quite consistent with the predictions.

When the three group-level shock variables are added to the model with village-time dummies (Column 3), the estimated coefficients for two individual housing damage variables increase in magnitude – neither of them is still statistically significant – and crop damage loses its statistical significance, indicating that the omission of group-level shock variables causes bias. Indeed, households in a kin group with more complete housing damages intensify fishing – the marginal effect is 1% for a 1 % increase in the proportion of victims in the same group (equivalently about 10% for an additional victim in an average tokatoka with 10 member households). The partial housing damage and crop damage at the group level exhibit no significant impacts.

When observable village-level variables are used (Column 4), the estimated coefficients for household- and group-level variables do not change almost at all and those for the village-level variables are very similar to Column (2). The only exception is that the estimated coefficient for the village-level complete housing damage decreases by 11% or equivalently by almost the same magnitude of the impact of the group-level complete housing damage. This indicates that households more strongly respond to the village-level complete damage than the group-level damage.

Disaggregated results for households without and with housing damaged are reported in Columns (5)-(8). Further disaggregated results for those with housing partially damaged which consist of 85% victims (Columns 9 and 10) are almost the same as those for all victims (to separately analyze the remaining 28 households with housing completely damaged is infeasible). As results are almost the same between models with village-time dummies and with observable village-level variables, only the latter are reported. First of all, victims intensify fishing to earn extra income to help make contributions to the village for rehabilitation; non-victims do not need to do so. While impacts of village-level complete housing damage and food aid are similar between non-victims and victims, group-level complete housing damage only influences non-victims and partial damage positively and negatively affects non-victims and victims, respectively. These findings suggest multilayered risk-sharing patterns: at the village level, recipients are households with housing completely damaged and donors are those with housing undamaged and partially damaged; at the kin group level, recipients are both of these two victims and donors are non-victims.

Households with housing partially damaged thus play dual roles: on one hand, they decrease fishing against group-level partial housing damage as they rely on help offered by non-victims in the same group; on the other hand, they intensify fishing to help others with severer damage in the same village as non-victims do. Since complete housing damage is relatively uncommon and nonexistent in some kin groups and the magnitude of this shock is too large to be shared among kin members, the larger-scale risk sharing at the village level plays a main role. Indeed, non-victims' fishing response to village-level complete housing damage is much stronger than that to group-level. Also only victims are affected by tarpaulin, indicating the larger role played by non-victims as donors than victims with partial damage. On the other hand, partial housing damage is much more common and occurs in most kin groups and the moderate magnitude of this shock can be shared within the group. Indeed, non-victims' fishing response to village-level partial housing damage is even negative. The models with mataqali-level shock variables generate very similar results. Hence, the resource-augmentation effect of ex post fishing exists mostly within tokatoka (a sub-group of mataqali).

Are the resource-augmentation effects found a robust result? Regarding the village-level effect captured by observable village-level shocks, it depends on whether they are correlated with unobservable time-variant covariate factors. Fishing competition and fish prices are potentially important. Fishing competition in the customary fishing area occurs among all villagers not among tokatoka or mataqali members and fish prices mostly follow three local markets depending on village location. If victims lower fishing efforts to free labor for rehabilitation, the competition among fishers will decrease and the reduced supply of fish may boost fish prices in comparison to other products, thereby encouraging fishing among non-victims. That is, housing damages may be negatively and positively correlated with unobserved competitions and relative prices, respectively. If competition or price actually mattered, non-victims' responses to village-level housing damages should be stronger than victims'; however, the converse holds true for partial damage and their responses to complete damage are very similar to each. Of course, possibilities of other confounding effects cannot be ruled out.[6] On the other hand, unobservable village-level factors do not cause bias in the estimates of household responses to kin-group shocks, because the results are almost the same between the

[6] For example, village-level housing damage (especially complete damage) may be correlated with damages on infrastructure that affected the transport of produce to local markets, but most damaged roads were recovered at the time of interviews. Institutional change could matter, but no fishing regulations were altered after the cyclone.

models with observable village-level shocks and with village-time dummies. Hence, the resource-augmentation effect at the kin-group level is likely to be robust.

I consider two fixed effects which can make household ex post labor responses heterogeneous – fishing capital and gender. As fishing capital determines returns to labor, the role of fishing as self-insurance may be asset-dependent. As in other developing regions, share fishing is relatively common in the study area: households that are poor in fishing capital work with others with large holdings in exchange for a share of the catch. Then, the resource-augmentation effect may depend on group members' capital holdings (if share fishing is done among them). In addition, although inequalities are often considered to be an important determinant of the use of commons and mixed results on their effects are found (e.g., Baland and Platteau, 1997; Alix-Garcia, 2008), how they influence the insurance role of commons has not been examined in the literature. I add individual shock variables interacted with individual capital holdings per adult equivalent (log) to the models (1) and (2) and group-level shock variables interacted with their group means and coefficient variations (standard deviations divided by means) to the model (2). No significant results on these interaction terms are found (results are not shown). As discussed above, household characteristics are distinct in the gender sphere and the sharp gendered division of labor exists in handicraft making (women) and labor sharing (men). I add individual shock variables interacted with a dummy for female head except complete housing damage which was experienced by a limited number of the female headed. I find no significant results (results are not shown).

Trimmed least squared estimates for log handicraft sales per adult equivalent per month – in six main participant villages – are reported in Table 4. The models with village-time dummies – with and without interaction terms with the female head dummy – are shown. As all results with tokatoka- and mataqali-level shocks are very similar to each other, only the former are reported. While the overall fitness of the models is not strong in periods 1 and 2, households with more crop damage sell more handicrafts in period 3 with no gendered difference (the interaction term is insignificant) and the female headed also do so in period 4 (only the interaction term is significant). Without interaction terms, crop damage is insignificant in period 4: that is, ignoring the gendered heterogeneity fails to capture the strong coping response of the female headed. With no a priori reason for the across-gender disparity in recall bias, this gendered difference is very unlikely to be a biased result. No kin-group shocks exhibit significant results in a robust manner. When observable village-level variables are used, almost none of them are significant and all other results are almost the same as what are presented here.[7]

I argue that these distinct patterns between handicraft selling and fishing are caused by households' private adjustments to cyclone relief. With generous food aid, the demand for self-insurance against crop damage is not high but households still need extra cash. Although there are significant variations in crop damages among households, information problems constrain risk sharing (crop rehabilitation involves no sharing). Handicraft selling is attractive self-insurance because it is low-risk-low-return but more value-added than NTFP gathering and it can be done individually by women when males are overwhelmed by labor-sharing tasks. However, handicrafts do not serve as insurance under emergency; mutual insurance probably plays a central role as exemplified by co-

---

[7] I ran the same regressions among households with housing damaged, finding similar results to those for the whole sample. It was infeasible to analyze the non-victim sample because of the small number of observations and the uncommon participation after the cyclone in some villages.

residence for refugees. The demand for handicraft selling as insurance becomes high when they are waiting for the harvest of rehabilitated crops in the lean period 3. To compensate for the proportionally greater crop damage than the male headed, the female headed boost production in period 4 when their labor constraint becomes less tight.

With very limited public support for housing rehabilitation, victims seek large extra cash to purchase construction materials (and tarpaulins) as well as labor support for repair. Most victims rely on mutual insurance supported by non-victims as potential donors. Lack of information problems and randomness in housing damage facilitate risk sharing. Fishing is too risky for self-insurance even among large fishing capital holders. Although cyclone relief – both tarpaulins and food aid – is of great help, it is not sufficient for victims. To augment risk sharing donors exploit rich marine resources to earn extra cash at least at the time of interviews – whether they also did so earlier is unknown. This augmentation is not affected by capital holdings among risk-sharing members. Lastly, with limited public support for village rehabilitation, households make significant contributions and fishing helps those with housing damaged do so.

5. Conclusion

This paper examined how forest and marine resources serve as insurance against a tropical cyclone using original household data gathered in rural Fiji. The fixed-effects estimator for a censored dependent variable controlled for unobservable household heterogeneity that could cause bias. I proposed a simple empirical strategy, which can be widely applied, to test whether a household intensifies labor activity to earn extra income to be shared under private risk-sharing arrangements. I found that while households abandon forest product gathering right after the cyclone, value-added handicrafts made of some forest products by women serve as self-insurance against crop damage after the emergency period and this is especially so among female-headed households who experienced proportionally greater damage than male-headed. Fijians intensify fishing to augment mutual insurance for the recovery from village facility damage and housing damages experienced by others (six to nine months after the cyclone). The risk-sharing arrangements are multilayered: not only households without housing damaged fish more to help others with severe damage in the same village and others with severe and less severe damage in the same kin group within the village, but also households with less severe damage do so to help others with severe damage in the same village. I discussed how the distinct patterns of natural insurance across resources and shocks emerged as private adjustments to cyclone relief delivered to the region over time.

These findings are context-specific but they still lead to the following general policy implications. First, with value-adding process natural insurance may play a significant role even in resource-poor environments. In some locales like Fiji development of handicraft enterprises and markets is probably promising for both income enhancement and better safety nets especially among poor women. Second, focusing on the self-insurance role of nature may lead to incomplete or wrong understanding of its broader role because it can be tightly linked with mutual insurance. This indicates the importance of integrating community-based resource management and safety-net policy. For example, such an approach helps avoid local overexploitation of commons under pressure, potential pitfall of natural insurance. In Fiji, however, kin groups which determine land and sea tenures do not necessarily match with risk-sharing groups. Coordinated managements of forest and marine resources are surely needed but in practice they are quite separated as in other locales. Third, right after the disaster, people do not resort to forest – with or without value-adding process – probably because mutual insurance plays a greater role under emergency (the insurance role of sea at that time is unknown though). While emergency relief is of great help, policy makers need to note that it may significantly alter informal mechanisms as recipients make adjustments.

References

Agarwal, B. (1990), 'Social security and the family in rural India coping with seasonality and calamity', *Journal of Peasant Studies* **17**: 341-412.

Alix-Garcia, J. (2008), 'An Exploration of the Positive Effect of Inequality on Common Property Forests', *Journal of Development Economics* **87**: 92-105.

Baland, J.-M. and P. Francois (2005), 'Commons as Insurance and the Welfare Impact of Privatization', *Journal of Public Economics* **89**: 211-31.

Baland, J.-M. and J.-P. Platteau (1997), 'Wealth inequality and efficiency in the commons: part I: the unregulated case', *Oxford Economic Papers* **49**: 451-482.

Bertram, G. (1986), 'Sustainable development in Pacific microeconomies', *World Development* **14**: 809-822.

Campbell, J.R. (1984). *Dealing With Disaster: Hurricane Response in Fiji*, Honolulu: Pacific Islands Development Program, East-West Centre.

Chapman, M.D. (1987), 'Women's fishing in Oceania', *Human Ecology* **15**: 267-370.

De Weerdt, J. and S. Dercon (2006), 'Risk-Sharing Networks and Insurance Against Illness', *Journal of Development Economics* **81**: 337-56.

Delacote, P. (2007), 'Agricultural expansion, forest products as safety nets, and deforestation', *Environment and Development Economics* **12**: 235-249.

Dercon, S. and P. Krishnan (2005). 'Food Aid and Informal Insurance', in S. Dercon, (ed.) *Insurance Against Poverty*, Oxford and New York: Oxford University Press, pp. 305-329.

Fafchamps, M. and S. Lund (2003), 'Risk-sharing networks in rural Philippines', *Journal of Development Economics* **71**: 261-287.

Fisher, M. and G. Shively (2005), 'Can Income Programs Reduce Tropical Forest Pressure? Income Shocks and Forest Use in Malawi', *World Development* **33**: 1115-28.

Honoré, B.E. (1992), 'Trimmed LAD and Least Squares Estimation of Truncated and Censored Regression Models with Fixed Effects', *Econometrica* **60**: 533-65.

Jodha, N.S. (1986), 'Common property resources and rural poor in dry region of India', *Economic and Political Weekly* **21**: 1169-1181.

Kochar, A. (1999), 'Smoothing consumption by smoothing income: hours-of-work responses to idiosyncratic agricultural shocks in rural India', *Review of Economics and Statistics* **81**: 50-61.

McSweeney, K. (2005), 'Natural Insurance, Forest Access, and Compounded Misfortune: Forest Resources in Smallholder Coping Strategies before and after Hurricane Mitch, Northeastern Honduras', *World Development* **33**: 1453-71.

Morduch, J. (2005). 'Consumption Smoothing across Space: Testing Theories of Risk-Sharing in the ICRISAT Study Region of South India', in S. Dercon, (ed.) *Insurance Against Poverty*, Oxford and New York: Oxford University Press, pp. 38-58.

Morris, S.S., O. Neidecker-Gonzales, C. Carletto, M. Munguia, J.M. Medina, and W. Wodon (2002), 'Hurricane Mitch and the Livelihoods of the Rural Poor in Honduras', *World Development* **30**: 49-60.

National Disaster Management Office (2003). 'Report on Tropical Cyclone Ami', Ministry of Regional Development, Fiji, Suva.

Pattanayak, S. and E. Sills (2001), 'Do tropical forests provide natural insurance? The microeconomics of non-timber forest product collection in the Brazilian Amazon', *Land Economics* **77**: 595-612.

Ravuvu, A. (1983). *Vaka I Taukei: The Fijian Way of Life*, Suva: Institute of Pacific Studies.

Rose, E. (2001), 'Ex ante and ex post labor supply response to risk in a low-income area', *Journal of Development Economics* **64**: 371-388.

Rosenzweig, M.R. (2001), 'Savings behavior in low-income countries', *Oxford Review of Economic Policy* **17**: 40-54.

Takasaki, Y., B.L. Barham, and O.T. Coomes (2004), 'Risk coping strategies in tropical forests: floods, illness, and resource extraction', *Environmental and Development Economics* **9**: 203-224.

Townsend, R.M. (1994), 'Risk and insurance in village India', *Econometrica* **62**: 539-591.

Turner, J.W. (1986), '"The water of life": kava ritual and the logic of sacrifice', *Ethnology* **25**: 203-214.

Turner, J.W. (1987), 'Blesses to give and receive: ceremonial exchange in Fiji', *Ethnology* **26**: 209-219.

Table 1. Household income, characteristics, and cyclone damage.

	All	Male head	Female head	Mean/ prop. test (p-value)
Sectoral income per adult equivalent per month a year ago - pre-cyclone (F$):				
Cropping	60.2 (90.8)	64.5 (95.2)	28.5 (35.0)	***0.019***
Fishing	32.1 (44.8)	30.4 (30.7)	44.9 (28.1)	*0.054*
NTFP gathering and handicraft selling[a]	1.2 (3.6)	1.2 (1.2)	1.0 (1.1)	*0.744*
Permanent wage labor[a]	10.7 (41.8)	11.5 (11.4)	4.4 (5.0)	*0.311*
Casula wage labor[a]	0.5 (3.2)	0.4 (0.4)	1.1 (0.7)	*0.201*
Other[b]	6.9 (44.5)	7.1 (7.1)	5.6 (6.4)	*0.841*
Total	112 (118)	115 (115)	85.5 (73.8)	*0.136*
Current sectoral income per adult equivalent per month - post-cyclone (F$):				
Cropping	34.9 (59.6)	37.3 (37.1)	17.3 (19.8)	***0.047***
Fishing	21.6 (33.6)	21.9 (22.0)	18.7 (19.7)	*0.571*
NTFP gathering and handicraft selling[a]	3.2 (10.6)	2.2 (2.1)	10.7 (9.8)	***0.000***
Permanent wage labor[a]	10.1 (40.9)	10.9 (10.8)	4.5 (5.1)	*0.351*
Casula wage labor[a]	0.9 (5.4)	0.8 (0.8)	1.2 (0.6)	*0.665*
Other[b]	3.0 (12.3)	2.7 (2.8)	5.0 (5.7)	*0.282*
Total	73.7 (83.2)	75.9 (75.8)	57.5 (60.8)	*0.189*
Household characteristics a year ago - pre-cyclone:				
Land per adult equivalent (acre)	1.1 (1.5)	1.2 (5.0)	0.6 (2.5)	***0.013***
Fishing capital per adult equivalent (F$)	107 (423)	98 (444)	174 (638)	*0.290*
Adults' secondary education dummy	0.83 (0.37)	0.85 (0.86)	0.70 (0.74)	***0.015***
Household size (adult equivalent)	4.9 (2.2)	4.9 (4.9)	4.4 (4.6)	*0.126*
Age of household head	48.6 (13.9)	47.0 (47.0)	59.5 (60.0)	***0.000***
Female head dummy	0.12 (0.33)	0.00 (0.00)	1.00 (1.00)	*n.a.*
Cyclone damages:				
Housing damaged dummy	0.53 (0.50)	0.53 (0.53)	0.53 (0.51)	*0.913*
Housing partially damaged dummy	0.45 (0.50)	0.45 (0.44)	0.45 (0.49)	*0.987*
Housing completely damaged dummy	0.08 (0.28)	0.09 (0.09)	0.08 (0.03)	*0.821*
Proportion of refugees right after the cyclone (among households with housing damaged)	0.37 (0.48)	0.37 (0.37)	0.43 (0.39)	*0.574*
Crop damaged dummy	0.86 (0.35)	0.87 (0.87)	0.78 (0.89)	*0.107*
Crop damage per adult equivalent (F$)	34.4 (44.7)	35.1 (35.0)	28.7 (32.8)	*0.396*
Housing rehabilitation (among households with housing damaged):				
Complete dwelling repair dummy	0.59 (0.49)	0.65 (0.65)	0.43 (0.46)	***0.027***
New housing construction dummy	0.09 (0.29)	0.06 (0.06)	0.03 (0.03)	*0.349*
No. observations	332	292	40	

[a] Pre-cyclone and pos-cyclone sectoral incomes are for periods 1 and 4, respectively.

[b] Other income consists of shop profit, livestock selling, and other self-employment activities like middleman.

Note: Household means are shown along with standard deviations in parentheses. t-test and chi-squared tests compare the means and proportion for continuous and dummy variables, respectively. Test results are italicized and those with a 5% significance level are bolded.

Table 2. Household NTFP gathering, handicraft sales, and cyclone relief.

	Pre-cyclone	Post-cyclone		
	Period 1	Period 2	Period 3	Period 4
NTFP gaterhing (in six main participant villages, n=223):				
Participation				
All	0.58 (0.49)	0.00 (0.07)	0.11 (0.32)	0.22 (0.41)
Male head	0.59 (0.49)	0.01 (0.07)	0.10 (0.30)	0.21 (0.41)
Female head	0.55 (0.51)	0.00 (0.00)	0.19 (0.40)	0.26 (0.44)
Proportion test (p-value)	*0.116*	*0.652*	*0.288*	*0.893*
Revenues per adult equivalent per month (F$)				
All	0.81 (2.72)	0.00 (0.00)	0.29 (1.20)	0.81 (3.48)
Male head	0.88 (2.89)	0.00 (0.00)	0.26 (1.23)	0.88 (3.72)
Female head	0.35 (1.11)	0.00 (0.00)	0.47 (1.03)	0.40 (1.15)
Mean test (p-value)	*0.162*	*0.655*	*0.568*	*0.372*
Handicraft sales (in six main participant villages, n=223):				
Participation				
All	0.12 (0.33)	0.12 (0.32)	0.19 (0.39)	0.22 (0.42)
Male head	0.11 (0.31)	0.11 (0.31)	0.18 (0.39)	0.20 (0.40)
Female head	0.19 (0.40)	0.16 (0.37)	0.23 (0.43)	0.39 (0.50)
Proportion test (p-value)	*0.064*	*0.182*	*0.329*	*0.083*
Revenues per adult equivalent per month (F$)				
All	0.73 (3.29)	0.53 (2.34)	1.23 (3.87)	3.86 (12.2)
Male head	0.72 (3.47)	0.53 (2.47)	1.26 (3.97)	2.31 (7.39)
Female head	0.83 (1.80)	0.55 (1.35)	1.03 (3.26)	13.5 (25.5)
Mean test (p-value)	*0.378*	*0.608*	*0.799*	***0.000***
Cyclone relief (whole sample, n=332):				
Tarpaulin receipt dummy		0.08 (0.27)	0.04 (0.19)	0.00 (0.00)
Food aid receipt dummy[a]		0.77 (0.42)	0.79 (0.41)	0.70 (0.46)
Food aid per month (days)[a]		9.6 (8.5)	9.5 (8.1)	9.9 (10.1)

[a] For period 4, the mean in five villages excluding other four in which interviews were conducted late period 4 are shown.

Note - Household means are shown along with standard deviations in parentheses. t-test and chi-squared tests compare the means and proportion for continuous and dummy variables, respectively. Test results are italicized and those with a 5% significance level are bolded.

Table 3. Determinants of log fishing revenues per adult equivalent per month - First-difference.

	All				Housing undamaged		Housing damaged		Housing partially damaged	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Household-level shocks										
Housing partially damaged dummy	-0.087	-0.088	-0.141	-0.141						
	(0.093)	(0.093)	(0.094)	(0.094)						
Housing completely damaged dummy	-0.126	-0.127	-0.276	-0.276			-0.024	-0.083		
	(0.154)	(0.155)	(0.192)	(0.191)			(0.165)	(0.170)		
Log crop damage (F$)	0.066 **	0.066 **	0.064	0.064	0.053	0.045	0.068 *	0.050	0.049	0.028
	(0.033)	(0.033)	(0.043)	(0.043)	(0.048)	(0.058)	(0.040)	(0.059)	(0.045)	(0.067)
Village-level shocks										
Proportion of housing partially damaged in the village		-0.641		-0.875 **	-1.526	-2.546 ***	-0.134	0.325	-0.461	0.109
		(0.623)		(0.423)	(0.998)	(0.860)	(0.841)	(0.375)	(0.932)	(0.473)
Proportion of housing completely damaged in the village		6.522 ***		5.782 ***	6.253 *	4.401 *	6.869 **	6.569 **	6.209 *	5.493 *
		(2.390)		(1.830)	(3.277)	(2.262)	(3.419)	(2.901)	(3.630)	(3.033)
Village mean of log crop damage		-0.019		-0.058	-0.338	-0.468	0.151	0.041	0.122	0.024
		(0.204)		(0.182)	(0.326)	(0.306)	(0.266)	(0.196)	(0.294)	(0.212)
Village mean of log food aid (days)		-0.907 ***		-0.918 ***	-1.069 **	-1.125 **	-0.904 **	-0.863 ***	-0.851 *	-0.794 **
		(0.301)		(0.238)	(0.470)	(0.419)	(0.401)	(0.307)	(0.449)	(0.346)
Proportion of tarpaulin received in the village		-2.463 **		-2.481 **	-1.025	-0.225	-2.965 *	-3.086 **	-2.671 *	-2.787 *
		(1.218)		(0.968)	(2.060)	(1.790)	(1.532)	(1.426)	(1.580)	(1.456)
Village facilities damaged dummy		0.269 *		0.273 **	0.010	-0.004	0.466 **	0.464 **	0.487 **	0.480 **
		(0.140)		(0.106)	(0.205)	(0.167)	(0.199)	(0.173)	(0.218)	(0.192)
Group-level shocks										
Proportion of housing partially damaged in the kin group			0.269	0.267		0.843 **		-0.389		-0.481 *
			(0.212)	(0.221)		(0.360)		(0.252)		(0.268)
Proportion of housing completely damaged in the kin group			0.962 **	0.956 **		1.467 ***		0.147		0.133
			(0.457)	(0.448)		(0.478)		(0.661)		(0.606)
Kin-group mean of log crop damage			0.036	0.036		0.052		0.165		0.155
			(0.076)	(0.078)		(0.131)		(0.125)		(0.133)
Village-time dummies	Yes	No	Yes	No	No	No	No	No	No	No
F (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.025	0.000
R squared	0.150	0.148	0.163	0.161	0.159	0.207	0.153	0.168	0.129	0.146
No. observations	664	664	664	664	310	310	354	354	298	298

Note: *10% significance, **5% significance, ***1% significance. Groups are tokatoka. Standard errors clustered by groups are inthe parentheses of clumns (3), (4), (6), (8), and (10). Robust standard errors are in the parentheses of other columns. All models inlcude a time dummy.

Table 4. Determinants of log handicraft revenues per adult equivalent per month - Trimmed least squares.

	Periods 1 and 2				Periods 1 and 3				Periods 1 and 4			
(n=446)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Household-level shocks												
Housing partially damaged	-0.73	-0.74	-0.72	-0.72	-0.43	-0.54	-0.45	-0.39	-0.44	-0.89	-0.32	-0.51
dummy	(0.46)	(0.47)	(0.60)	(0.59)	(0.55)	(0.46)	(0.45)	(0.44)	(0.56)	(0.58)	(0.55)	(0.54)
Housing completely damaged	0.31	0.78	0.29	0.31	0.81	0.98	0.77	1.12	3.25 **	1.90	1.68	0.95
dummy	(0.46)	(0.86)	(0.47)	(1.08)	(0.69)	(0.75)	(0.67)	(0.75)	(1.34)	(1.94)	(1.71)	(2.58)
Log crop damage per adult	0.21	0.23 *	0.25	0.26 *	0.39 ***	0.35 ***	0.46 ***	0.39 **	0.16	0.27	-0.03	-0.03
equivalent (F$)	(0.14)	(0.13)	(0.22)	(0.15)	(0.13)	(0.12)	(0.15)	(0.15)	(0.16)	(0.20)	(0.17)	(0.20)
Housing partially damaged			0.22	0.39			-0.05	-0.23			-0.99	-1.29
dummy*Female head dummy			(0.84)	(0.94)			(1.10)	(1.08)			(1.11)	(1.20)
Log crop damage per adult			-0.10	-0.28			-0.22	-0.30			0.52 *	0.58 **
equivalent*Female head dummy			(0.26)	(0.25)			(0.25)	(0.26)			(0.27)	(0.26)
Group-level shocks												
Proportion of housing partially		1.20		-0.81		1.16		0.78		4.35 *		2.40
damaged in the kin group		(2.77)		(1.60)		(1.30)		(1.84)		(2.42)		(2.68)
Proportion of housing completely		-1.88		3.99 *		0.32		0.25		1.72		0.94
damaged in the kin group		(3.13)		(2.24)		(2.22)		(3.62)		(3.66)		(5.87)
Kin-group mean of log crop		0.15		0.76		0.65		1.51 *		0.85 *		0.74
damage per adult equivalent		(0.54)		(0.65)		(0.46)		(0.88)		(0.45)		(1.03)
Wald (p-value)	0.022	0.063	0.033	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Loss function	19.3	20.2	21.0	35.3	38.7	53.3	43.3	46.5	82.7	88.0	103.4	134.3

Note: *10% significance, **5% significance, ***1% significance. Groups are tokatoka. Robust standard errors are in parentheses. All models inlcude a time dummy and village-time dummies.