Vulnerability of Household Consumption to Natural Disasters in Rural Pakistan*

Takashi Kurosaki†

September 2010

Abstract

What kind of households are vulnerable in the sense that their consumption had to decline when their villages were hit by natural disasters? This question is investigated using two-period panel data from rural Pakistan, surveyed in 2001 and 2004, covering about 1,600 households. The natural disasters addressed are floods, droughts, and pest attacks. During this period, average consumption increased, associated with a decrease in poverty and an increase in inequality. Nevertheless, the aggregate figure conceals a more micro picture, in which some households suffered from a severe decline in their welfare due to idiosyncratic or village-level covariate shocks. Motivated by a full risk sharing model, empirical models allowing for heterogenous household responses to natural disasters are derived and applied to the two period panel data. Empirical results show that the sensitivity of consumption changes to village-level shocks differs across regions, depending upon the nature of disasters and the characteristics of households. Land is effective in mitigating the ill-effects of various types of disasters. Consumption of Northern Punjab villagers are more vulnerable to droughts while Southern Punjab villagers are more vulnerable to pest attacks and Sindh villagers are more vulnerable to floods. Judging from the fact that the average consumption is much higher in Northern Punjab than in Southern Punjab and Sindh, we speculate that risk-coping measures against droughts in Southern Punjab and Sindh could be very expensive, sacrificing the expected income, but still not very effective against floods.

1 Introduction

In July-August 2010, Pakistan experienced "the worst floods in its history... The floods have affected 84 districts out of a total 121 districts in Pakistan, and more than 20 million people — one-tenth of Pakistan's population... More than 1,700 men, women and children have lost their lives, and at least 1.8 million homes have been damaged or destroyed" (UN 2010, p.1). In attacking poverty in developing countries, due considerations need to be paid to the vulnerability of households against natural disasters. Poor households are likely to suffer not only from low income and consumption on average but also from fluctuations of their welfare once such disasters occur. These households are vulnerable to a decline in their welfare level because they have limited ability to cope with shocks and also they are

*Very preliminary. Please do not quote without the authors' permission.

†Institute of Economic Research, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo 186-8603 Japan. E-mail: kurosaki@ier.hit-u.ac.jp.

subject to substantial shocks, such as weather variability (Dercon, 2005; Fafchamps, 2003). This concern has led to an emerging literature on vulnerability measures in development economics (Ligon and Schechter, 2003; 2004; Kamanou and Morduch, 2005; Calvo and Dercon, 2005; Kurosaki 2006a). We broadly think people as vulnerable when (i) they cannot mitigate income volatility and (ii) their consumption expenditure is volatile over time (they lack reliable coping mechanisms). Vulnerability is thus a forward-looking concept.

As an example of low-income countries subject to substantial vulnerability, this paper examines the case of Pakistan. Pakistan is located in South Asia, where more than 500 million people or about 40% were estimated to live below the poverty line at the turn of the century (World Bank, 2001). Economic development in South Asia has been characterized by a moderate success in economic growth with a substantial failure in human development such as basic health, education and gender equality (Drèze and Sen, 1995). This characteristic is most apparent in Pakistan (World Bank, 2002). Although the overall economic growth rates were improved during the 2000s, poverty reduction was slower than expected. Using a two-period panel dataset spanning three years from the North-West Frontier Province (NWFP),[1] one of the four provinces comprising Pakistan, Kurosaki (2006a) and Kurosaki (2006b) show that rural households were indeed vulnerable to substantial welfare fluctuations. Using a three-year panel dataset from Pakistan's Punjab, Kurosaki (1998) shows that farmers' consumption was excessively sensitive to idiosyncratic shocks to their non-farm income. Similar findings have been accumulated for rural India as well (Townsend, 1994; Kurosaki 2001).

One shortcoming of this literature is its focus on the welfare impacts of *idiosyncratic* shocks. This focus has led to econometric specifications in which all village-level shocks are often controlled through fixed effects, thus throwing the village-level co-movement of income shocks and consumption into a black box. This is unsatisfactory, especially considering the growing importance of aggregate shocks in affecting the welfare of villagers in the process of globalization. As Sawada (2007) summarizes, the impact of idiosyncratic risks and that of nondiversifiable aggregate risks that characterize a disaster are distinctively different and the role of self-insurance becomes more important against large-scale disasters because formal or informal mutual insurance mechanisms are largely ineffective. However, rigorous study of the impact of natural disasters on household welfare is lacking for the case of Pakistan.

This paper attempts to fill in this gap in the literature through investigating the question: What kind of households in rural Pakistan are vulnerable in the sense that their consumption had to decline when their villages were hit by natural disasters, such as floods, droughts, and pest attacks? In other words, this paper attempts to characterize vulnerability against

[1] In April 2010, the constitution of Pakistan was amended, including the renaming of the former NWFP as "Khyber Pakhtunkhwa." In this paper, since all data correspond to a period before this constitutional amendment, the expression "NWFP" is used to infer the current province of "Khyber Pakhtunkhwa."

village-level shocks through looking at the past changes in welfare due to such shocks. Since the 2010 Pakistani Flood is simply unprecedented, this paper cannot address or predict its impact precisely. Nevertheless, the investigation of the past experiences could shed light on the vulnerability characteristics in a qualitative way.

The remainder of the paper is organized as follows. The next section explains an empirical model to estimate the vulnerability of household consumption to natural disasters, derived from the theory of risk sharing and intertemporal optimization. The data are described in Section 3 — a two-period panel dataset from rural Pakistan, surveyed in 2001 and 2004, covering about 1,600 households. During this period, average consumption increased, associated with a decrease in poverty and an increase in inequality. The econometric results are presented in Section 4. Section 5 concludes the paper, with a speculation on the potential impact of the 2010 Pakistani Flood on household welfare.

2 Analytical Framework

2.1 Theoretical Model

The empirical analyses of this paper are based on a standard model of a household (denoted i), which optimizes its forward looking welfare defined as

$$W_{it} = U_i(c_{it}) + E_t\left[\sum_{\tau=1}^{T}\left(\frac{1}{1+\delta}\right)^{\tau} U_i(c_{i,t+\tau})\right], \tag{1}$$

where $U(.)$ is an instantaneous utility function that satisfies $U'(.) > 0, U''(.) < 0$, δ is the subjective discount rate, and $E[.]$ is an expectation operator. In period t, household i allocates resources across consumption, investment, production, etc., in order to maximizes W_{it} subject to endowments and technology constraints.

The key assumption is risk aversion ($U''(.) < 0$). Because of risk aversion, households would choose a completely smoothed consumption path even if their income path is fluctuating, when the income path is exogenous and pre-determined (no uncertainty) and when they are faced with perfect credit markets (i.e., they can borrow or lend any amount of money at the same interest rate). Under perfect credit markets, when there is exogenous but stochastic fluctuation in the income levels, their consumption path is fairly smoothed and responsive to income shocks only partially to the uninsured idiosyncratic risk. On the other hand, when households are faced with credit (or liquidity) constraint, which is likely to be binding when the households' cash in hand is low, their consumption path cannot be smoothed from the current period to the next period (Deaton, 1991). Similarly, under a full risk sharing regime within a village, the household consumption path is fairly smoothed with no response to idiosyncratic shocks, while it becomes more volatile when risk sharing is incomplete (Townsend, 1994; Kurosaki et al. 2010).

As a benchmark, this paper departs from Kurosaki's (2001) full risk sharing model within a village among heterogenous villagers. This model extends Townsend's (1994) model by allowing heterogenous risk preference among villagers. Assuming CRRA preference, i.e., $U_i(c_i) = \frac{1}{1-R_i} c_i^{1-R_i}$, where R_i is an Arrow-Pratt coefficient of relative risk aversion (heterogeneous risk preference),[2] an optimal consumption is defined as

$$\ln c_{it} = -\frac{1}{R_i} \ln \mu_t + \frac{1}{R_i} \ln \lambda_i + \frac{1}{R_i} t \ln \frac{1}{1+\delta} = \alpha_i' \bar{\ln} c_t + \beta_i', \tag{2}$$

where μ_t is the Lagrange multiplier associated with the resource constraint in the village in period t, λ_i is a Pareto-Negishi weight for household i, $\bar{\ln} c_t$ is the village mean of log consumption, and α_i' and β_i' are defined as

$$\alpha_i' \equiv \frac{1}{R_i} \left[\frac{1}{N} \sum_j \frac{1}{R_j} \right]^{-1}, \tag{3}$$

$$\beta_i' \equiv \frac{1}{R_i} \left[\ln \lambda_i - \frac{1}{N} \sum_j \alpha_j \ln \lambda_j \right], \tag{4}$$

where N is the number of households in the village. Equation (2) intuitively shows that the optimal consumption consists of a variable part proportional to the village mean consumption at the rate of α_i' and a fixed part β_i'. Definition (3) implies that when a household is more risk averse than the village average in the sense that $\frac{1}{R_i} < \frac{1}{N} \sum_j \frac{1}{R_j}$, α_i' becomes smaller than unity, i.e., the household's share in variable consumption is smaller than the village average. Definition (4) implies that the village economy allocates consumption to households according to the size of λ_i. Although the weights can take any positive values under the social planner's optimization framework, there exists a mapping from the consumption allocation under a full-information competitive equilibrium to the consumption allocation under the social planner's problem with a specific vector of λ. Under such competitive equilibrium, wealthier households who can contribute more to the village income on average are likely to be assigned higher λ_i and hence higher consumption.

2.2 Empirical Model

Motivated by the theoretical model above, an empirical model is proposed to examine the sensitivity of log consumption growth with respect to aggregate and idiosyncratic shocks. A straightforward way of implementing this examination based on equation (2) is to estimate

$$\Delta \ln c_{it} = b_i + a_i \Delta \bar{\ln} c_t + \zeta_i X_{it} + u_{it}, \qquad i = 1, ..., N, \quad t = 1, ..., T, \tag{5}$$

[2] Since Kurosaki (2001) found no evidence for heterogenous time preference for South Asian households, this paper assumes homogenous time preference.

where $\Delta \ln c_t = \ln c_t - \ln c_{t-1}$, b_i, a_i, and ζ_i are parameters to be estimated, X_{it} denotes idiosyncratic income shocks to household i, and u_{it} is an error term with zero mean. Parameter ζ is allowed to vary among households since functioning of risk sharing arrangements may differ from household to household.

This model is an extension of the excess sensitivity of household-level consumption to idiosyncratic shocks after controlling for village-level aggregate shocks (Townsend, 1994; Kurosaki, 2006a). At the same time, the extent to which household consumption responds to income shocks is itself an interesting parameter, and can be interpreted as a measure of vulnerability (Amin et al., 2003; Skoufias and Quisumbing, 2005).

An important empirical implication from the previous subsection is that, even when a first difference is used as the dependent variable, household specific effects remain. Parameter a_i corresponds to the effects due to heterogeneity in risk preferences. When panel data are available with rich variation in the village-level and household-level shocks, equation (5) can be estimated by a time series regression for each household when the time horizon of panel data is sufficiently long. When the time horizon of panel data is short, which is the case in this paper, equation (5) cannot be estimated without further restrictions on b_i, a_i, and ζ_i.

Since our panel dataset covers only two period and our focus is on the heterogenous impact of village-level shocks, the empirical model is specified as

$$\Delta \ln c_{it} = X_i \beta + Z_v Z_i \gamma + \epsilon_{it}, \tag{6}$$

where X_i is a vector of household characteristics such as physical assets owned by the household, income sources, credit access, education level of the household head, and demographic composition, Z_v is a vector of village-level production shock variables (negative shocks such as floods, droughts, etc.) for household i living in village v, Z_i is a subset of X_i used as a shifter for the household's ability to cope with village-level shocks, β and γ are vectors of parameters to be estimated, and ϵ_{it} is a zero mean error term. Both X_i and Z_i include the intercept term. Vector β shows which type of households are more likely to increase/decrease their consumption while vector γ shows which of household attributes Z_i is associated with a larger decline in consumption if the village is hit by a production shock Z_v. Therefore, vector γ is of main interest of this paper. The impact of idiosyncratic shocks are partially controlled by $X_i \beta$ and partially attributed to the error term, since we do not have direct measures of idiosyncratic shocks in our dataset.

Under the full risk sharing model with (potentially) heterogenous risk preference, the finding of statistically significant shifter in Z_v is interpreted as evidence for the heterogeneity in risk preference. For instance, if education has a negative coefficient in γ for the flood shock dummy, it means that the consumption decline due to floods is larger among more educated households, suggesting that the educated are able to behave in a less risk-averse way in the optimal village-level risk sharing thanks to their higher human capital position.

The interpretation of the estimation results of (6) need not be based on the full risk sharing model with heterogenous risk preference. Households are likely to be involved in both risk sharing arrangements with villagers and self-insurance arrangements using asset accumulation. Allowing this possibility, if the landholding has a positive coefficient in γ for the flood shock dummy (the consumption decline due to the flood is attenuated among landholders), it suggests that landholders are able to use their land assets for self-insurance. Unfortunately, the empirical model in this paper cannot distinguish between the two mechanisms underlying the partial consumption smoothing. Nevertheless, the information on which households are associated with an attenuated consumption decline when their village is hit by natural disasters, say a flood, is itself an empirically interesting one. For this reason, we estimate the model (6) as it is. More structural analysis distinguishing the risk sharing route and the self-insurance route is left for further analysis.

3 Data

3.1 Characteristics of Pakistan's economy

Pakistan is a federal state comprising four provinces of Punjab, Sindh, NWFP, and Balochistan. In general, Punjab and Sindh are regarded as economically advanced provinces, while NWFP and Balochistan are regarded as backward provinces. One difficulty in comparing the four provinces is the imbalance in their sizes. In terms of population as well as production, Punjab is the largest, occupying more than a half of the national economy. Sindh is the second largest accounting for 23% of the national population, followed by NWFP, accounting for 14%. Balochistan is the largest in terms of area (about 45% of Pakistan's area) but the smallest in terms of population (only 4% of the national population). The isolation and remoteness of Balochistan makes it difficult to obtain reliable data on this province.

Another dimension of spatial disparity in Pakistan is the difference in living standards between urban and rural areas. About 30% of the Pakistani population live in urban areas. Even after adjusting for differences in prices, income and expenditure levels in urban areas are much higher than in rural areas. Urban Punjab and urban Sindh are thus regarded as the most advanced regions. Urban-rural disparity is the largest in Sindh, whose rural regions are lagging behind in various aspects, characterized by a few big landlords and numerous landless sharecroppers.

Although declining, the share of agriculture in Pakistan's GDP is still high at over 20%

(Government of Pakistan, various issues). There are two crop seasons: *Kharif* and *Rabi*.[3] Since Pakistan is mostly located in semi-arid and arid zones, crop production in both seasons is highly dependent on irrigation. In spite of the fact that Pakistan has the largest irrigated agriculture in the world in terms of acreage, agricultural output fluctuates substantially (Kurosaki, 1998). This is because the canal water availability depends on rainfall in the Himalaya, which fluctuates every year, and the irrigation water availability at the farm level is disrupted frequently due to management problems in the irrigation system. In addition to the agricultural sector, agro-industries (such as cotton-based textiles) and agro-services (such as trade of agricultural produce) are important in non-agricultural sectors. Because of this, Pakistan's macroeconomy as a whole also fluctuates substantially, depending on the weather.

Using four rounds of nationally-representative, repeated cross-section data (PIHS/PSLM data), surveyed by the Federal Bureau of Statistics, the Government of Pakistan, in 1998/99, 2001/02, 2004/05, 2005/06, Kurosaki (2009) characterizes the changes in average consumption, inequality measures, and poverty measures. The results show that the average consumption declined initially, followed by increases in the next two periods. The annual growth rate (exponential) from 1998/99 to 2005/06 was 1.56% while that from 2001/02 to 2005/06 was 4.80%. The movement of average consumption in Pakistan is closely related with agricultural production. The year 2001/02 was associated with the worst agricultural output in recent years. The agricultural production recovered in the next two years, culminating in 2004/05, the bumper harvest year in recent years. FGT poverty measures moved in the opposite way — but there are regional heterogeneity: urban and rural Punjab and rural NWFP were most successful in reducing poverty continuously, while rural Sindh and urban/rural Balochistan experienced volatile changes in poverty measures. During this period, inequality decreased from 1998/99 to 2001/02, then it increased rapidly from 2001/02 to 2004/05.

3.2 PRHS panel data

As a unique panel dataset from Pakistan with a relatively large sample size, this paper employs micro data from PRHS ("Pakistan Rural Household Survey" conducted jointly by the Pakistan Institute of Development Economics and the World Bank). The first round (PRHS-I) was surveyed from September 2001 to January 2002, collecting information on agricultural related activities for the crop seasons of *Kharif* 2000 and *Rabi* 2000/01, and consumption information corresponding to the month preceding the survey. About 2,700 households living in rural areas were surveyed, spreading all four provinces of Pakistan.

[3] *Kharif* is a monsoon season whose harvests come in September-November, while *Rabi* is a dry season whose harvests come in March-June. Rice, cotton, and maize are major crops in *Kharif* while wheat and gram pulse are major crops in *Rabi*.

Three years after, the second round (PRHS-II) was surveyed from August 2004 to October 2004, covering agricultural crop seasons of *Kharif* 2003 and *Rabi* 2003/04, and consumption in the month preceding the survey. Because of security problems and other reasons, sample households in NWFP and Balochistan were not re-surveyed.

From the PRHS panel data, nominal consumption expenditure[4] per capita[5] in Pakistan Rupees is calculated and then converted into a real term by dividing by the official poverty line.[6] This is the concept known as the "welfare ratio" and denoted as c_{it} below, where subscript i refers to individual i and t refers to the survey year. In a static analysis of poverty, individuals with $c_{it} \geq 1$ are classified as non-poor and those with $c_{it} < 1$ are classified as poor. The official poverty line of Pakistan is close to the level of 1 PPP$/day (1.25 PPP$/day in 2005 price), which is adopted widely in the international comparison.

In this paper, the balanced panel of 1,609 households (929 in Punjab and 680 in Sindh) are employed, for which complete consumption information was available in both surveys. In PRHS-I, the number of sample households in Punjab and Sindh with complete consumption information was 1,874, implying the attrition rate at 14%.

In PRHS-I, the sample households were randomly drawn from sample villages and the sample villages were chosen as broadly representative of each province. Therefore, if the attrition was purely random, the PRHS panel data are broadly representative of rural Punjab and Sindh. Comparing the panel households with those who dropped out of PRHS, we found that the average of c_{it} in PRHS-I among the attritted sample was 12% lower than that among the panel sample, and the difference was statistically significant (p value = 0.029). On the other hand, household size and compositions were similar between the two groups (the difference was statistically insignificant). This suggests a possibility of weak attrition bias in that initially poor households were more likely to drop out of the sample.

Table 1 shows three welfare measures based on the PRHS panel data: average of c_{it}, poverty measures, and Atkinson's (1970) inequality measures. Because there is a socioeco-

[4]Since many farm households in Pakistan are subsistence-oriented and many rural laborer households are paid sometimes in kind, the value of these in-kind transactions were carefully imputed in calculating the consumption expenditure.

[5]To be precise, "per capita" means "per adult equivalence unit," which is the unit adopted by the Government of Pakistan to establish the official poverty line. Individuals who are 18 years old or above are assigned the weight of 1.0 and others are assigned that of 0.8.

[6]The official poverty line was converted into the poverty line for each PRHS round in four steps: First, the poverty headcount rate for rural Punjab and Sindh was estimated at 38.5% using PIHS 2001/02 data and the official poverty line. Second, the poverty line for PRHS-I was fixed to generate the same poverty headcount rate using PRHS-I data for rural Punjab and Sindh, including the households who dropped out in the re-survey. Third, an inter-temporal inflation rate of 15.2% between PRHS-I and PRHS-II was estimated by weighting monthly CPIs by the number of observations for each corresponding month for PRHS-I and PRHS-II data. Fourth, the poverty line for PRHS-II was fixed by multiplying the PRHS-I poverty line by the inflation rate.

nomic gap between northern and southern parts of Punjab, we divide Punjab into two.[7] The change between PRHS-I (2001) and PRHS-II (2004) are similar to the trends between PIHS 2001/02 and PSLM 2004/05, which are nationally representative. The poverty measures decreased substantially from 2001 to 2004. The decrease was slightly larger in Sindh than in Northern and Southern Punjab, reducing the gap between the two provinces. In both Punjab and Sindh, inequality increased during this period. This is similar to the change observed in nationally representative household surveys between 2001/02 and 2004/05. Table 1 thus demonstrates that there is a clear ranking of average well-beings among the three regions: Northern Punjab at the top, Sindh at the bottom, and Southern Punjab in between.

3.3 Poverty transition at the household level

To utilize the advantage of panel data, Table 2 classifies sample households by their status of poverty *transition*. Out of 1,609 sample households, 182 were below the poverty line in both periods ("chronically poor"), 342 were below the poverty line in PRHS-I but above it in PRHS-II ("getting out of poverty"), 176 were above the poverty line in PRHS-I but below it in PRHS-II ("falling into poverty"), and 909 were equal to or above the poverty line in both periods ("never poor"). In terms of individual population, 13.4% of the PRHS-I individuals belonged to the "chronically poor" households, 23.7% to the "getting out of poverty" households, 11.6% to the "falling into poverty" households, and 51.2% to the "never poor" households.

In terms of transition probability, 65.3% of households who were initially poor became non-poor in PRHS-II, while 16.2% of households who were initially non-poor became poor three years after. Therefore, we observe high level of poverty mobility. The vulnerability measured by the incidence of falls into poverty is thus very high in rural Pakistan. The transition probability from non-poor to poor was higher in Sindh (23.5%) than in Southern Punjab (16.3%) and Northern Punjab (9.9%). Note that these falls occurred when the average poverty headcount ratio decreased. The aggregate figure thus conceals a more micro picture, in which some households suffered from a severe decline in their welfare due to idiosyncratic or village-level shocks.

The comparison of three regions shows that dwellers in rural Sindh were more vulnerable than those in rural Punjab. This regional contrast in vulnerability is found robustly from other methodologies applied to the same panel data (see, e.g., Arif and Bilquees, 2008;

[7] There is no official division of Punjab into North Punjab and South Punjab. Among 35 districts in Punjab, six districts were surveyed in PRHS, from which three districts of Attock, Faisalabad, and Hafizabad are classified as "Northern Punjab" and three districts of Bahawalpur, Muzaffargarh, and Vehari are classified as "Southern Punjab" in this paper. Out of 22 districts in Sindh, the PRHS data cover four districts of Badin, Larkana, Mirpur Khas, and Nawabshah.

Kurosaki, 2009).

4 Sensitivity of Consumption Changes to Village-level Shocks

4.1 Empirical variables

One shortcoming of the transient poverty analysis in Table 2 is that it does not take into account changes in consumption that occurred without crossing the poverty line. The consumption level of some of the "never poor" might have been very stable while that of others might have been fluctuating year by year. Then it could be better to regard the latter type as (potentially) more vulnerable than the former type. Another issue is that some of the observed change in consumption levels would have been anticipated by the household. If this is the case, we need to decompose the observed changes in consumption into anticipated and unanticipated components. The correlates of the observed changes in consumption are thus analyzed in this section, based on the empirical model (6). Since there are only two periods in our panel dataset, equation (6) is estimated as a cross-section regression model.

This empirical model shows what kind of household attributes in X_i are associated with a larger decline in consumption in the face of natural disasters. In this sense, this is one measure of vulnerability. Similar specification was adopted in empirical studies on vulnerability such as Ravallion (1995), Jalan and Ravallion (1999), and Glewwe and Hall (1998). As controls, vector X_i includes variables such as physical assets owned by the household (farmland, livestock, the sum of the value of durable consumption goods, transportation equipment, house buildings, etc.), income sources (number of male working members engaged in non-farm work, existence of remittance receipt, etc.), credit access, education level of the household head, and demographic composition (number of household members, female ratio among them, and dependency ratio among them).[8]

As proxy for Z_v, production shocks at the village level, 24 variables were available in PRHS-II, all of which assessed the negative impact due to natural disasters in five points: 0 ("No effect": no report for the crop damage), 1 ("Little effect": yield loss up to 10%), 2 ("Moderate": 10-25% loss), 3 ("Severe": 25-50% loss), and 4 ("Disaster": more than 50% loss). Three types of disasters were investigated: drought; flooding; and pest attack. Eight cropping seasons up to the survey reference period (i.e., from *Kharif* 2000 to *Rabi* 2003/04) were covered. The incidence of these disasters are shown in Table 3. Droughts are the most common among the three types of disasters and they occurred in all three regions with

[8] Regarding education and landholding, dummy variables distinguishing zero and positive years of education or positive acreage of owned land were attempted as well, yielding results very similar to those reported in this paper. Regarding the access to non-farm jobs, variables characterizing female workers engaged in non-farm jobs were not included because the average was close to zero and the variation was very small.

similar frequency. On the other hands, flood damages were not reported from Northern Punjab, they were reported but only infrequently from Southern Punjab. In other words, floods occurred most frequently in Sindh. In contrast, pest damages concentrate in Southern Punjab, followed by Northern Punjab. The occurrence of pest damages is infrequent in Sindh.

After attempting several ways of aggregating the twenty-four variables, we report the results with three aggregated variables for drought, flood, and pest in two agricultural years of 2002/03 and 2003/04, normalized between zero and one. The robustness of our results with respect to this definition will be investigated later. Definition and summary statistics of empirical variables are summarized in Table 4. Since the consumption data in PRHS-II were collected in August-October 2004, the agricultural output in 2002/03-2003/04 should have affected the consumption most directly. Production shocks that occurred before these two years might have affected the consumption level reported in PRHS-I. For this reason, we use the last two years' shocks as village-level shocks that are exogenous to the initial consumption and unanticipated by villagers. Nationally, 2003/04 was a normal harvest year. Nevertheless, this does not mean that all villages experienced a normal harvest. As shown in Table 3, several villages suffered from drought and pest attack and fewer villages suffered from floods. How responsive to these shocks was the consumption of residents in these villages, relative to villages that did not report such shocks? This question is addressed below.

4.2 Estimation results

Table 5 shows the estimation results of equation (6), first without cross-terms and then with cross-terms involving regional dummies. The second specification clarifies the regional contrast. Both of the regression models show that the variation in X_i and Z_v does not explain well the variation in consumption growth (i.e., low R^2), which is common in the literature on consumption growth empirics. Nevertheless, F test statistics for the null hypothesis of zero slopes show clearly that the empirical model is not statistically rejected.

Looking at specification (i), among household characteristics X_i, four variables are found to have statistically significant coefficients: the size of owned land (negative), the number of male household members who were employed permanently in regular non-farm jobs (positive), remittance receiving dummy (positive), and the dependency ratio (positive). The finding that households with larger landholding were lagging behind in consumption growth seems to suggest that growth from 2001 to 2004 was not very land-based. We might be tempted to interpret that the second finding to show that households with more access to non-farm permanent employment were less vulnerable to stochastic consumption decline.

However, the positive coefficient may simply reflect the life-cycle improvement in earnings associated with non-farm permanent jobs (e.g., regular promotion). The positive impact of remittance on consumption growth is also consistent with prior expectation. The fourth finding that households with more dependent household members experienced higher growth in consumption may simply reflect the fact that children (the majority among the dependent members) require larger amount of consumption after they become three years older.[9] All other variables are insignificant. The proxy variables for informal credit constraints have a positive sign, as expected from the theoretical model (Deaton, 1991), but the coefficients were statistically insignificant. The impact of household characteristics remains qualitatively the same when we introduce the cross-terms of natural disasters and regional dummies (see specification (ii) of Table 5). The remittance dummy now has a more significant, positive coefficient.

Regarding coefficients on village-level production shocks, the coefficients on natural disasters are all negative in specification (i), without cross terms. However, their statistical significance level was low — at the 10% level for pest attacks and at the 20% level for droughts and floods (not statistically significant in a conventional sense). The magnitudes are in the range of -0.112 to -0.166, implying that consumption of villagers are likely to decline by around 10 to 20% when hit by a natural disaster destroying 50% (or more) of crops in *Kharif* and *Rabi*. Comparing with the size of the damage, the consumption decline seems relatively small, suggesting a moderate level of insurance against village-level shocks.

To examine whether regional difference exists regarding the extent of consumption smoothing ability against natural disasters, specification (ii) in Table 5 allows the coefficient on Z_v to differ across three regions. Since no incidence of flood was reported from Northern Punjab, the cross terms involving floods are only for Southern Punjab and Sindh. Regarding the effect of drought, the negative impact was economically and statistically significant for Northern Punjab, while it was mitigated in both Southern Punjab and Sindh, resulting in the statistical insignificance. One interpretation is that since drought is an every-day occurrence in Southern Punjab and Sindh and it does not damage transportation nor personal assets much, villagers have institutionalized a means to isolate their consumption from the ill-effects of drought on farm income. Candidates for such a means may include inter-village transfers, credit transactions, and migration. This is a topic worth further investigation.

The ill-effects of floods are highly negative in both Southern Punjab and Sindh. In Southern Punjab, however, due to infrequent occurrence of floods in our dataset (see Table 3), the coefficient is statistically insignificant. In sharp contrast, floods in Sindh lead to a

[9] When we subdivide the sample into the relatively rich and the relatively poor by the median of the welfare ratio, *depratio* has a positive and significant coefficient only among the former. It is negative and statistically insignificant among the poor. This seems to support the life cycle interpretation.

significant decline in consumption. Unlike droughts, floods are likely to disrupt transportation and damage properties. This could be a reason that villagers in Sindh do not have a means to isolate their consumption from the ill-effects of floods. The magnitude is also very large: consumption of villagers in Sindh are likely to decline by around 30% when hit by a flood destroying 50% (or more) of the crop. Since the starting level of consumption in rural Sindh is much lower than in other regions and poverty measures are higher in Sindh than in other regions, a 30% cut in their consumption is likely to lead to a severe survival crisis.

Regarding the effect on consumption of pest attack in the farm, the impact in Northern Punjab was insignificant, while it was significantly negative in Southern Punjab. This seems to reflect the importance of cotton crops (inherently vulnerable to pest attacks) in Southern Punjab. Southern Punjab residents are thus highly vulnerable to pest attacks. The reason for an unexpectedly positive coefficient in Sindh is not clear.

The null hypothesis that the impact of village-level shocks is the same in all regions is rejected at the 1% level. Therefore, spatial heterogeneity in marginal impacts of natural disasters is supported.

To further entangle the heterogeneity in the marginal impact of a natural disaster, household-level characteristics were interacted with the village-level shocks (Table 6). Among the fifteen household-level variables, seven are chosen as the potential shifter of the marginal impact. Four of them (land holding size, number of household members employed in non-agriculture on the permanent base, dummy for remittance receipt, and the dependency ratio) are those variables in X_i in equation (6) with robustly significant coefficients (see Table 5). The rest three (dummy for credit constraint in the formal sector, age of the household head, and education level of the household head) are those variables found to be associated with other measures of vulnerability analyzed by Kurosaki (2009). In specification (i) of Table 6, the regression results with all these cross-terms are reported, while in specification (ii), the model was made parsimonious by deleting statistically insignificant interaction terms in specification (i).

The results show the followings. Younger households and households with many dependent members were able to more isolate their consumption from drought-driven income decline; the ill-effects of flooding are mitigated if a household is more landed, the household head is younger, and household head is less educated; and the ill-effects of pest attacks are mitigated if a household is more landed, without remittance receipt, without formal credit access, and older. The impact of landholding is thus found to be vulnerability-reducing regardless of the type of disasters. This confirms the value of landholding in Pakistan's rural economy. On the ill-impact of pest attacks, household's access to remittance and formal credit has the effect opposite to the expectation. Regarding the impact of remittance, the reverse causality may be suspected since the variable was calculated from households' income sources in 2003/04, not in PRHS-I — Because households were hit by pest attack, they received more remittance but the increased remittance was not sufficient to cancel its damage. Although the credit access information is from PRHS-I, similar reverse causality could be suspected if the credit access in PRHS-I is highly correlated with that in PRHS-II. Regarding the effect of education, it tends to increase the marginal response to floods, which is consistent with the full risk sharing model — the consumption decline due to the flood is larger among more educated households, suggesting that the educated are able to behave in a less risk-averse way in the optimal village-level risk sharing thanks to their higher human capital position.

The null hypothesis that the impact of village-level shocks is the same across different household characteristics is rejected at the 1% level. Therefore, the marginal impacts of natural disasters are heterogenous, consistent with both the imperfect credit market model and the model of full risk-sharing among heterogenous villagers.

4.3 Robustness of the empirical results

The results in Tables 5-6 were found robust to various alterations. First, different definitions of natural disaster variables were attempted. Considering the possibility that only major disasters should be counted, indices corresponding to the larger of the last two years instead of their averages are used (specification (1)-(i),(ii),(iii) in Table 7). Without no cross-terms, the estimated magnitudes are similar to those in Table 5 — coefficients were in the range of -0.114 to -0.163, implying that consumption of villagers are likely to decline by around 10 to 20% when hit by a natural disaster destroying 50% of the crop. Notably, now all three coefficients are statistically significant. When regional cross-terms are included, we confirmed the previous finding of vulnerability of Northern Punjab villagers against drought, vulnerability of Southern Punjab villagers against pest attacks, and vulnerability of Sindh villagers against floods. When cross-terms with household characteristics are included, vulnerability-reducing impacts of landholding were robustly found.

Considering the possibility that only the most recent disasters matter for the current consumption, indices corresponding to the last agricultural year instead of the averages of the last two years were also attempted (specification (2)-(i),(ii),(iii) in Table 7). Both the size and sign of each coefficient are very similar to those reported earlier. In specification (i), without cross-terms, the ill-effects of droughts is now statistically significant. On the other hand, in both (i) and (ii) specifications,the statistical significance of flood shocks is reduced.

As a different direction of robustness check, different weights were employed in running the houseohld-level regression. In the default specifications, we used the number of household members in the initial period as the weight to convert the regression results consistent with individual-based aggregates. Since the household size for some households changed between the two surveys, weights based on the second round survey and weights based on the average of the two were attempted. Since the results were very close to those reported here, they are omitted for brevity.

To sum up, the sensitivity of consumption changes to village-level farm production shocks differs across regions, depending upon the nature of shocks and the characteristics of households. Land is effective in mitigating the ill-effects of various kinds of natural disasters, while other characteristics are vulnerability-reducing or vulnerability-increasing depending on the type of natural disasters. Consumption levels of Northern Punjab villagers are more vulnerable to drought than those in Southern Punjab and Sindh. Judging from the fact that the average c_{it} is much higher in Northern Punjab than in Southern Punjab and Sindh, we speculate that risk-coping measures against drought in Southern Punjab and Sindh could be very expensive, sacrificing the expected income, but still not very effective against floods.

5 Conclusion

This paper investigated what kind of households in rural Pakistan are vulnerable in the sense that their consumption had to decline when their villages were hit by natural disasters. The natural disasters addressed are floods, droughts, and pest attacks. The regression results associating observed changes in consumption to household characteristics and village-level disaster variables showed the followings. The sensitivity of consumption changes to village-level farm production shocks differs across regions, depending upon the nature of shocks and the characteristics of households. More landed households seem to be less vulnerable to all these shocks. Consumption of Northern Punjab villagers are more vulnerable to droughts than those in Southern Punjab and Sindh, while consumption of Sindh villagers are more vulnerable to floods than those in Northern Punjab. Judging from the fact that the average consumption is much higher in Northern Punjab than in Southern Punjab and Sindh, we speculate that risk-coping measures against droughts in Southern Punjab and Sindh could be very expensive, sacrificing the expected income. Furthermore, risk-coping measures available for Sindh villagers were not very effective against floods, which are likely to disrupt transportation and damage properties.

What is the implications of these findings for the 2010 Pakistani Flood case? Our best estimate for the impact of floods on consumption is a 10 to 20% decline on average across regions but as high as a 30% decline in Sindh, where the consumption level is low. Although these ill-effects are already large enough, we should interpret them as the lower bound, since these estimates are based on data where only regional floods were observed in the recent past. When unprecedented floods spread all over the country, risk-coping across regions becomes very difficult, resulting in a huge loss of welfare. The investigation in this paper cannot assess this aspect, which requires data and methodologies different from those used in this paper.

Restricting the focus on the empirical investigation of the impacts of village-level shocks in the past, several extensions are worth attempting. First, welfare indicators other than consumption or alternative definition of consumption can be defined and examined. Second, distinguishing risk-sharing and self-insurance empirically remains an important challenge. Third, investigation of welfare costs of natural disasters on longer terms through (human) capital investment is highly called for. These are left for further research.

References

Amin, S., A.S. Rai, and G. Topa (2003). "Does Microcredit Reach the Poor and Vulnerable? Evidence from Northern Bangladesh," *Journal of Development Economics* 70(1): 59-82.

Arif, G.M. and F. Bilquees (2008). "Chronic and Transitory Poverty in Pakistan: Evidence from a Longitudinal Household Survey," mimeo, Pakistan Institute of Development Economics, Islamabad.

Atkinson, A.B. (1970). "On the Measurement of Inequality," *Journal of Economic Theory* 2: 244-263.

Calvo, C. and S. Dercon (2005). "Measuring Individual Vulnerability," Department of Economics Discussion Paper Series No.229, Oxford University, March 2005.

Deaton, A. (1991). "Saving and Liquidity Constraints," *Econometrica* 59(5): 1221-48.

Dercon, S. (ed.) (2005). *Insurance Against Poverty*, Oxford: Oxford University Press.

Drèze, J. and A.K. Sen (1995). *India: Economic Development and Social Opportunity*, Delhi: Oxford University Press.

Fafchamps, M. (2003). *Rural Poverty, Risk and Development.* Cheltenham, UK: Edward Elger.

Glewwe, P. and G. Hall (1998). "Are Some Groups More Vulnerable to Macroeconomic Shocks than Others? Hypothesis Tests Based on Panel Data from Peru," *Journal of Development Economics* 56(1): 181-206.

Government of Pakistan (various issues). *Pakistan Economic Survey.* Islamabad: Ministry of Finance, Government of Pakistan.

Jalan, J. and M. Ravallion (1999). "Are the Poor Less Well Insured? Evidence on Vulnerability to Income Risk in Rural China," *Journal of Development Economics* 58(1): 61-81.

Kamanou, G. and J. Morduch (2005). "Measuring Vulnerability to Poverty," in Dercon (2005): 155-175.

Kurosaki, T. (1998). *Risk and Household Behavior in Pakistan's Agriculture* Tokyo: Institute of Developing Economies.

—— (2001). "Consumption Smoothing and the Structure of Risk and Time Preferences: Theory and Evidence from Village India," *Hitotsubashi Journal of Economics* 42(2): 103-117.

—— (2006a). "Consumption Vulnerability to Risk in Rural Pakistan," *Journal of Development Studies* 42(1): 70-89.

—— (2006b). "The Measurement of Transient Poverty: Theory and Application to Pakistan," *Journal of Economic Inequality* 4(3): 325-345.

—— (2009). "Vulnerability in Pakistan, 2001 - 2004," March 2009, Background paper for the Pakistan Poverty Assessment Project, the World Bank.

Kurosaki, T., K. Kurita, and E. Ligon (2010). "Intertemporal Choice and Inequality in Low-Income Countries: Evidence from Thailand, Pakistan, and India," Mimeo, July 2010, Hitotsubashi University, Tokyo, Japan (paper presented at the 2010 NEUDC Conference, MIT).

Ligon, E. and L. Schechter (2003). "Measuring Vulnerability," *Economic Journal* 113: C95-C102.

—— (2004) "Evaluating Different Approaches to Estimating Vulnerability," Social Protection Discussion Paper Series No.04101, World Bank.

Ravallion, M. (1995). "Household Vulnerability to Aggregate Shocks: Differing Fortunes of the Poor in Bangladesh and Indonesia," in K. Basu, P. Pattanaik, and K. Suzumura (eds.), *Choice, Welfare, and Development: A Festschrift in Honour of Amartya K. Sen*, Oxford, Clarendon Press: 295-312.

Sawada, Y. (2007). "The Impact of Natural and Manmade Disasters on Household Welfare", *Agricultural Economics* 37(s1): 59-73.

Skoufias, E. and A.R. Quisumbing (2005). "Consumption Insurance and Vulnerability to Poverty: A Synthesis of the Evidence from Bangladesh, Ethiopia, Mali, Mexico and Russia," *European Journal of Development Research* 17(1): 24-58.

Townsend, R.M. (1994). "Risk and Insurance in Village India," *Econometrica* 62(3): 539-591.

UN (2010). *Pakistan Floods Emergency Response Plan*, September 2010, United Nations.

World Bank (2001). *World Development Report 2000/2001: Attacking Poverty*, Oxford University Press.

—— (2002). *Pakistan Poverty Assessment – Poverty in Pakistan: Vulnerability, Social Gaps, and Rural Dynamics*, Report No. 24296-PAK, October 2002.

Table 1. Average consumption, poverty, and inequality measures based on expenditures in Pakistan

	PRHS-I (2001)	PRHS-II (2004)
1. Average welfare ratio		
Punjab and Sindh pooled (rural only)	**1.465**	**1.846**
	(0.0288)	(0.0380)
By regions		
Northern Punjab	**1.848**	**2.190**
	(0.0637)	(0.0700)
Southern Punjab	**1.546**	**1.886**
	(0.0646)	(0.0991)
Sindh	**1.175**	**1.617**
	(0.0280)	(0.0430)
2. Poverty Measures		
Punjab and Sindh pooled (rural only)		
Headcount index	**0.372**	**0.259**
	(0.01381)	(0.01278)
Poverty gap index	0.0950	0.0680
	(0.00475)	(0.00434)
Squared poverty gap index	0.0354	0.0260
	(0.00233)	(0.00215)
Headcount index by regions		
Northern Punjab	**0.196**	**0.154**
	(0.02041)	(0.01851)
Southern Punjab	**0.361**	**0.267**
	(0.02643)	(0.02409)
Sindh	**0.490**	**0.318**
	(0.02188)	(0.02088)
3. Atkinson inequality measures		
Punjab and Sindh pooled (rural only)	**0.359**	**0.425**
	(0.0118)	(0.0126)
By regions		
Northern Punjab	**0.336**	**0.394**
	(0.0186)	(0.0220)
Southern Punjab	**0.359**	**0.461**
	(0.0269)	(0.0318)
Sindh	**0.305**	**0.392**
	(0.0148)	(0.0157)

Notes: The inequality aversion parameter for Atkinson's inequality measure is set at 3. Conventional standard errors are reported in parenthesis for the average welfare ratio and poverty measures, while bootstrapped standard errors (the number of replications is 500) are reported in parenthesis for inequality measures. Statistics are weighted so that figures represent individual-level summary statistics.

Source: Calculated by the author from the PRHS panel data (NOB=1,609).

Table 2. Household-level poverty transition from 2001 to 2004

	Status in PRHS-II (2004)		
Status in PRHS-I (2001)	Below *z*	Above *z*	Total
Punjab and Sindh pooled (rural only)			
Number of sample households			
Below *z*	182	342	524
Above *z*	176	909	1,085
Total	358	1,251	1,609
Transition probability (%)			
Below *z*	34.7	65.3	100.0
Above *z*	16.2	83.8	100.0
Northern Punjab			
Number of sample households			
Below *z*	27	58	85
Above *z*	42	383	425
Total	69	441	510
Transition probability (%)			
Below *z*	31.8	68.2	100.0
Above *z*	9.9	90.1	100.0
Southern Punjab			
Number of sample households			
Below *z*	50	80	130
Above *z*	47	242	289
Total	97	322	419
Transition probability (%)			
Below *z*	38.5	61.5	100.0
Above *z*	16.3	83.7	100.0
Sindh			
Number of sample households			
Below *z*	105	204	309
Above *z*	87	284	371
Total	192	488	680
Transition probability (%)			
Below *z*	34.0	66.0	100.0
Above *z*	23.5	76.5	100.0

Note: "*z*" is the poverty line corresponding to the official one (see footnote 6).
Source: Calculated by the author from the PRHS panel data.

Table 3. Incidence of village-level production shocks

	Distribution of Damage Index* (%)									
	0	1	2	3	4	5	6	7	8	Total
Drought in the last year (Rabi 04 - Kharif 03)										
Northern Punjab	43.7	0.0	10.4	4.2	9.5	0.0	32.2	0.0	0.0	100.0
Southern Punjab	0.0	4.8	17.0	20.3	28.7	4.2	17.7	7.3	0.0	100.0
Sindh	61.7	0.0	11.9	8.4	5.3	3.3	2.9	4.5	2.0	100.0
Drought in the year before the last year (Rabi 03 - Kharif 02)										
Northern Punjab	50.8	0.0	7.1	3.5	3.0	0.0	35.5	0.0	0.0	100.0
Southern Punjab	4.0	4.8	14.2	36.4	10.8	24.8	5.1	0.0	0.0	100.0
Sindh	70.9	5.7	5.3	6.6	4.8	0.0	3.0	0.0	3.7	100.0
Drought in Rabi 02 - Kharif 01										
Northern Punjab	44.3	0.0	13.6	0.0	6.4	0.0	35.7	0.0	0.0	100.0
Southern Punjab	22.6	6.7	47.2	15.4	4.0	4.2	0.0	0.0	0.0	100.0
Sindh	75.2	4.5	2.5	0.0	7.7	0.0	3.0	0.0	7.1	100.0
Drought in Rabi 01 - Kharif 00										
Northern Punjab	85.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0	0.0	100.0
Southern Punjab	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Sindh	89.8	0.0	5.1	0.0	1.1	0.0	2.0	0.0	2.0	100.0
Flood in the last year (Rabi 04 - Kharif 03)										
Northern Punjab	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Southern Punjab	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Sindh	72.1	5.7	4.0	3.9	8.5	0.0	0.0	0.0	5.7	100.0
Flood in the year before the last year (Rabi 03 - Kharif 02)										
Northern Punjab	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Southern Punjab	90.7	4.8	0.0	4.5	0.0	0.0	0.0	0.0	0.0	100.0
Sindh	63.3	5.7	4.0	10.0	10.4	0.0	0.0	1.1	5.4	100.0
Flood in Rabi 02 - Kharif 01										
Northern Punjab	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Southern Punjab	95.8	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Sindh	87.1	0.0	0.0	4.0	0.0	0.0	3.4	0.0	5.4	100.0
Flood in Rabi 01 - Kharif 00										
Northern Punjab	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Southern Punjab	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Sindh	98.9	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	100.0
Pest attack in the last year (Rabi 04 - Kharif 03)										
Northern Punjab	22.8	9.5	12.5	24.0	2.9	3.8	15.2	0.0	9.3	100.0
Southern Punjab	0.0	0.0	4.9	4.2	16.6	65.4	3.8	0.0	5.1	100.0
Sindh	91.5	3.9	0.0	3.1	1.5	0.0	0.0	0.0	0.0	100.0
Pest attack in the year before the last year (Rabi 03 - Kharif 02)										
Northern Punjab	57.2	5.9	3.0	3.0	2.9	3.5	15.2	0.0	9.3	100.0
Southern Punjab	0.0	0.0	8.7	16.4	23.5	30.1	21.2	0.0	0.0	100.0
Sindh	96.1	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	100.0
Pest attack in Rabi 02 - Kharif 01										
Northern Punjab	53.7	9.5	5.9	0.0	2.9	3.5	15.2	0.0	9.3	100.0
Southern Punjab	0.0	14.7	37.7	35.1	8.0	4.5	0.0	0.0	0.0	100.0
Sindh	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Pest attack in Rabi 01 - Kharif 00										
Northern Punjab	82.1	0.0	0.0	2.9	2.9	0.0	12.1	0.0	0.0	100.0
Southern Punjab	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Sindh	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Source: Calculated by the author from the PRHS panel data (NOB=1,609).
Note: * Simple sum of the indices for Rabi and Kharif. The index takes 0 (``No effect": no report for the crop damage), 1 (``Little effect": yield loss up to 10%), 2 (``Moderate": 10-25% loss), 3 (``Severe": 25-50% loss), and 4 (``Disaster": more than 50% loss). So its sum is an integer from zero to eight.

Table 4. Summary statistics of empirical variables used in regression analyses

Variable	Definition	NOB	Mean	Std.Dev.	Min	Max
Dependent variable						
dlnc	Log difference of the welfare ratio between PRHS-I and PRHS-II.	1,293	0.169	0.606	-1.767	2.299
Explanatory variables: Household characteristics						
landacre	Size of farmland owned by the household (acres).	1,293	4.947	11.679	0	102
livslrg	Number of large livestock animals owned by the household.	1,293	2.496	3.019	0	21
livssml	Number of sheep and goats owned by the household.	1,293	1.816	3.935	0	50
assets	Value of assets (durable consumption goods, transportation equipment, house buildings, etc.) owned by the household (Rs.1,000).	1,293	20.000	56.992	0	2001
nfe_perm	Number of male household members who were employed permanently by the private sector, government, or police.	1,293	0.239	0.561	0	5
nfe_casl	Number of male household members who were employed in non-farm activities on daily or contract basis.	1,293	0.429	0.742	0	4
remit	Dummy for a household who received remittances from family members living separately.	1,293	0.055	dummy	0	1
cc_fml	Dummy for a household who were constrained to the formal credit access.#	1,290	0.682	dummy	0	1
cc_inf	Dummy for a household who were constrained to the informal credit access.#	1,290	0.101	dummy	0	1
head_age	Age of household head (years).	1,293	47.639	14.283	14	99
head_sch	Education level of household head (completed years of schooling).	1,243	2.791	3.849	0	21
head_fem	Dummy for a female-headed household.	1,293	0.018	dummy	0	1
femratio	The ratio of females in the household size.	1,293	0.482	0.143	0	1
depratio	The ratio of dependent members (aged <15 and >60) in the household size.	1,293	0.476	0.186	0	1
popwt1	Household size (Nos.).	1,293	8.957	4.443	1	42
Explanatory variables: Village-level agricultural production shocks						
drought	Index variable* for crop damage due to drought in Rabi 04, Kharif 03, Rabi 03, and Kharif 02.	1,293	0.279	0.281	0	1
flood	Index variable* for crop damage due to flood in Rabi 04, Kharif 03, Rabi 03, and Kharif 02.	1,293	0.076	0.161	0	0.9375
pest	Index variable* for crop damage due to pest attack in Rabi 04, Kharif 03, Rabi 03, and Kharif 02.	1,293	0.248	0.296	0	1

Notes: #Households were regarded as constrained if they needed to borrow from the formal (informal) sector and applied to the loan but rejected; or, if they needed to borrow from the formal (informal) sector but did not apply to the loan because the credit institutions are too far away, no guarantee available, no collateral, too much procedures, etc. The corresponding period for the formal loan is "ever until 2000/01" while that for the informal loan is "during 2000/01".

*The sum of index variables for the four seasons in Table 3 divided by 16. (1)Means and standard deviations (Std.Dev.) are weighted by the household size in PRHS 1 in order to obtain individual-level summary statistics. (2)All household-level variables are taken from the PRHS-I dataset, except for "remit", which corresponds to the remittance receipt in the agricultural year of 2003/04.

(1) The subsample used in the regression analyses is those households whose welfare ratio was smaller than four in both PRHS-I and PRHS-II and whose size changed by less than or equal to three persons during the two surveys. Because of this selection, the number of househlds in this table is at most 1,293, against 1,609 in Tables 1-2.

(2) Means and standard deviations (Std.Dev.) are weighted by the household size in PRHS 1 in order to obtain individual-level summary statistics.

(3) All household-level variables are taken from the PRHS-I dataset, except for "remit", which corresponds to the remittance receipt in the agricultural year of 2003/04.

Source: Calculated by the author from the PRHS panel data.

Table 5. Sensitivity of consumption changes to village-level production shocks

	Dependent variable: *dlnc* (change in log consumption)					
	(i) Without cross-terms			(ii) With cross-terms with regional dummies		
Explanatory variables	Coef.		S.E.	Coef.		S.E.
Household-level variables						
landacre	-0.00710	**	(0.00304)	-0.00754	**	(0.00312)
livslrg	-0.00348		(0.00713)	-0.00409		(0.00707)
livssml	-0.01003		(0.00653)	-0.00956		(0.00667)
assets	0.00015		(0.00022)	0.00006		(0.00016)
nfe_perm	0.10104	***	(0.03634)	0.09793	***	(0.03721)
nfe_casl	-0.00704		(0.02586)	-0.00402		(0.02560)
remit	0.13957	*	(0.07980)	0.16245	**	(0.08073)
cc_fml	0.04200		(0.04215)	0.02681		(0.04257)
cc_inf	0.03104		(0.05847)	0.05572		(0.05876)
head_age	0.00124		(0.00128)	0.00106		(0.00130)
head_sch	0.00214		(0.00522)	0.00207		(0.00525)
head_fem	-0.07377		(0.10621)	-0.10256		(0.10573)
femratio	-0.15907		(0.12448)	-0.18723		(0.12303)
depratio	0.23596	**	(0.09621)	0.23691	**	(0.09612)
popwt1	-0.00417		(0.00758)	-0.00350		(0.00770)
Village-level shocks						
drought	-0.11189		(0.07490)			
drought*North.Punjab				-0.30265	**	(0.13818)
drought*South.Punjab				0.15068		(0.17032)
drought*Sindh				-0.01123		(0.10385)
flood	-0.16584		(0.12444)			
flood*South.Punjab				-1.28541		(0.96481)
flood*Sindh				-0.33251	**	(0.14812)
pest	-0.14316	*	(0.07434)			
pest*North.Punjab				0.14424		(0.12966)
pest*South.Punjab				-0.44915	***	(0.14541)
pest*Sindh				0.70413	*	(0.39687)
Intercept	0.18927	*	(0.11105)	0.22015	**	(0.11088)
F-stat for zero slopes#	2.53	***		2.83	***	
F-stat for homogenous impact#				3.69	***	
R-squared	0.065			0.079		

Notes: NOB is 1,241 (several households whose "head_sch" was missing were dropped). Estimated by weighted least squares with household size as weights. Huber-White robust standard errors are reported in parenthesis, with * 10%, ** 5%, and *** 1% statistical significance levels.

"F-stat for zero slopes" shows the F statistics for the null hypothesis that the empirical model has no explanatory power. It is distributed as F(18,1222) for specification (i) and F(23,1217) for specification (ii) under the null. "F-stat for homogenous impact" shows the F statistics for the null hypothesis of specification (i) against specification (ii). It is distributed as F(5,1217) under the null.

Source: Estimated by the author from the PRHS panel data.

Table 6. Sensitivity of consumption changes to village-level production shocks and household characteristics

Explanatory variables	Dependent variable: *dlnc* (change in log consumption)			
	(i) Base specification		(ii) Parsimonious specification	
	Coef.	S.E.	Coef.	S.E.
15 household-level variables used in Table 5	(jointly significant at 1%)		(jointly significant at 1%)	
Village-level shocks and their cross-terms with household characteristics				
drought	0.07929	(0.34317)	0.08370	(0.30020)
drought*landacre	0.00433	(0.00835)		
drought*nfe_perm	-0.06817	(0.15337)		
drought*remit	-0.14661	(0.30026)		
drought*cc_fml	-0.08736	(0.16239)		
drought*head_age	-0.01017 **	(0.00513)	-0.00958 *	(0.00507)
drought*head_sch	-0.01403	(0.02148)		
drought*depratio	0.85338 **	(0.38145)	0.54661 *	(0.30909)
flood	1.09638 **	(0.50804)	0.70022 *	(0.39570)
flood*landacre	0.02413 **	(0.01100)	0.02799 ***	(0.00941)
flood*nfe_perm	0.20598	(0.31526)		
flood*remit	-0.19842	(0.79955)		
flood*cc_fml	-0.14690	(0.24425)		
flood*head_age	-0.01987 **	(0.00876)	-0.02038 **	(0.00848)
flood*head_sch	-0.03832 *	(0.02331)	-0.04102 *	(0.02156)
flood*depratio	-0.70844	(0.55448)		
pest	-0.15620	(0.32510)	-0.33228	(0.25386)
pest*landacre	0.01586 **	(0.00791)	0.01836 ***	(0.00635)
pest*nfe_perm	0.04155	(0.13495)		
pest*remit	-0.66260 **	(0.31232)	-0.74003 ***	(0.24220)
pest*cc_fml	-0.28364 *	(0.15822)	-0.31751 **	(0.12964)
pest*head_age	0.00808 *	(0.00473)	0.00791 *	(0.00470)
pest*head_sch	0.01415	(0.01993)		
pest*depratio	-0.53387	(0.37518)		
F-stat for zero slopes#	2.85 ***		3.82 ***	
F-stat for homogenous impact#	2.55 ***		5.96 ***	
R-squared	0.104		0.100	

Notes: NOB is 1,241 (several households whose "head_sch" was missing were dropped). Estimated by weighted least squares with household size as weights. Huber-White robust standard errors are reported in parenthesis, with * 10%, ** 5%, and *** 1% statistical significance levels.

"F-stat for zero slopes" shows the F statistics for the null hypothesis that the empirical model has no explanatory power. It is distributed as F(39,1201) for specification (i) and F(27,1213) for specification (ii) under the null. "F-stat for homogenous impact" shows the F statistics for the null hypothesis of specification (i) in Table 5 against specification (i) or (ii) in this table. It is distributed as F(21,1201) for (i) and F(9,1213) for (ii) under the null.

Source: Estimated by the author from the PRHS panel data.

Table 7. Robustness check on the impact of village-level production shocks

Explanatory variables	(i) Without cross-terms Coef.	S.E.	(ii) With cross-terms with regional dummies Coef.	S.E.	(iii) With cross-terms with hh. characteristics. Parsimonious spec. Coef.	S.E.
(1) Production shock variables correspond to the larger of the last two years (Rabi 04-Kharif 03 or Rabi 03-Kharif 02)						
drought	-0.11392 *	(0.06281)			-0.35694 **	(0.14924)
drought*North.Punjab			-0.20408 *	(0.10834)		
drought*South.Punjab			0.13756	(0.15067)		
drought*Sindh			0.00376	(0.09225)		
drought*depratio					0.54937 *	(0.28532)
flood	-0.16008 **	(0.07696)			-0.14909	(0.09101)
flood*South.Punjab			-0.60134	(0.48808)		
flood*Sindh			-0.30238 ***	(0.09485)		
flood*landacre					0.01307 **	(0.00628)
flood*head_sch					-0.03009 *	(0.01581)
pest	-0.16269 **	(0.06593)			0.01708	(0.11733)
pest*North.Punjab			0.00740	(0.10552)		
pest*South.Punjab			-0.44572 ***	(0.13175)		
pest*Sindh			0.44978 **	(0.22874)		
pest*landacre					0.01670 ***	(0.00633)
pest*remit					-0.70706 ***	(0.22760)
pest*cc_fml					-0.30712 **	(0.12595)
(2) Production shock variables correspond to the last year (Rabi 04 - Kharif 03)						
drought	-0.13057 **	(0.06539)			-0.41422 ***	(0.15843)
drought*North.Punjab			-0.23554 *	(0.12660)		
drought*South.Punjab			0.08790	(0.14182)		
drought*Sindh			-0.14298 *	(0.08512)		
drought*landacre					0.01126 *	(0.00608)
drought*depratio					0.51443 *	(0.29211)
flood	-0.11814	(0.10294)			0.62572 *	(0.33102)
flood*Sindh			-0.14158	(0.10214)		
flood*landacre					0.01745 **	(0.00770)
flood*head_age					-0.01531 **	(0.00686)
flood*head_sch					-0.04451 **	(0.01822)
pest	-0.16115 **	(0.06897)			0.01370	(0.12207)
pest*North.Punjab			0.04488	(0.12116)		
pest*South.Punjab			-0.43896 ***	(0.13073)		
pest*Sindh			0.09456	(0.32454)		
pest*landacre					0.01620 **	(0.00674)
pest*remit					-0.60691 **	(0.24130)
pest*cc_fml					-0.27575 **	(0.13071)

Dependent variable: *dlnc* (change in log consumption)

Notes & source: See Tables 5-6. Coefficients on household characteristics are omitted for brevity.