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Vulnerability of Household Consumption to Floods and Droughts in Developing Countries: Evidence from Pakistan

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Abstract:

Aggregate shocks such as droughts and floods cannot be perfectly insured by risk sharing within a village. Given this inability, what type of households are more vulnerable in terms of a decline in consumption when a village is hit by such shocks and what kind of microeconomic mechanism underlies the household heterogeneity in vulnerability? These questions are investigated using two-period panel data collected in rural Pakistan in 2001 and 2004. We compare consumption response to droughts, floods, and health shocks and investigate how the response differs across different types of households. Empirical results show that the impact of droughts was negligible, younger and more landed households were less vulnerable to floods, and households with greater access to formal financial institutions were less vulnerable to idiosyncratic health shocks. The empirical pattern suggests the possibility of risk sharing among households that are heterogeneous in both risk aversion and credit access.

JEL classification codes: O12, D12, D91.
Keywords: natural disaster, consumption smoothing, risk sharing, self-insurance, Pakistan.

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1 Introduction

Households in developing countries face a wide variety of risks arising from natural disasters. For instance, Pakistan, from which the household data are taken for this paper, experienced in July-August 2010 the worst floods in its history, which affected 84 districts out of a total 121 districts, killing more than 1,700 persons (United Nations, 2010). Disasters such as this could disable the entire household or village economy. To compound issues, the number of natural disasters reported appears to be increasing globally—it was less than 100 per year in the mid 1970s while it was approximately 400 per year during the 2000s according to the emergency events database (EM-DAT).[1] The same database lists the top 10 natural disasters in Pakistan for the period 1900 to 2013. According to it, five, seven, and eight disasters in the top 10 occurred during the 1990s and 2000s, respectively for the number of people killed, the number of total affected people, and the costs of economic damage. Floods and earthquakes are major disasters in these lists. This database thus appears to indicate more frequent occurrences of natural disasters in more recent years in Pakistan. On the other hand, colonial reports published by the British Government of India before Pakistan's independence in 1947 are full of statements on droughts, hailstorms, and floods.[2] These reports suggest that policymakers during the colonial period were highly sensitive to droughts that could result in a famine.

What have been the impacts of these disasters on developing economies? As summarized by Cavallo and Noy (2009) and Sawada (2007), the economic research on natural disasters and their consequences is fairly limited and the majority of such studies focus on macroeconomic impacts. For instance, using cross-country panel data, Noy (2009) shows that developing countries face much larger output declines following a disaster of similar relative

[1] Available on http://www.emdat.be/natural-disasters-trends (accessed on February 1, 2013). In interpreting such data, we should pay attention to the possibility that the reported increase is partly due to an increased tendency to report, not necessarily an increase in the occurrence of disasters.

[2] See a various issues of *Season and Crop Reports* published by the Government of Punjab, Sind (Bombay-Sind), and North-West Frontier Province since 1901/02.

magnitude than do developed countries or bigger economies, suggesting the importance of an increased ability to mobilize resources for reconstruction. Using similar cross-country panel data, Sawada et al. (2011) demonstrate that natural disasters have positive impacts on per-capita GDP in the long run, despite they generate large negative impacts in the short run. Coffman and Noy (2012) use a synthetic control methodology to estimate the long-term impacts of a 1992 hurricane on the island economy of Kauai, Hawaii, showing that Kauai's economy was yet to recover after 18 years of the event.

The macroeconomic studies mentioned above tend to treat the disaster as an economy-wide covariant shock and ignore within-country or within-village heterogeneity. However, it is likely that the damage and consequent welfare loss of a covariant shock differ from village to village within a region and from household to household within a village. This calls for the research on microeconomic impacts of natural disasters.

In development economics, there is an accumulation of theoretical and empirical studies focusing on households' ability to cope with risk. These studies have shown that poor households are likely to suffer not only from low levels of welfare on average but also from fluctuations in their welfare due to their limited coping ability (Fafchamps, 2003; Dercon, 2005). The inability to avoid welfare declines when hit by exogenous shocks can be called vulnerability, for which we have now a substantial literature on its measurement (Ligon and Schechter, 2003; Dercon, 2005; Kurosaki, 2006; Dutta et al., 2010). These studies tend to focus on the welfare impacts of *idiosyncratic* shocks. This focus has led to econometric specifications in which all village-level (or higher level) shocks are often controlled through fixed-effects. The use of village fixed effects implies that the magnitude and direction of the impact of each type of village-level shocks on household welfare are not identified separately but put into a black box. This is unsatisfactory, particularly when considering the growing influence of aggregate shocks on the welfare of villagers in the process of globalization and global warming. Furthermore, Ligon and Schechter (2003) demonstrate that aggregate risk is much more important than idiosyncratic sources of risk. Nevertheless, there has been less effort in microeconometric studies to explain the sources and impacts of aggregate shocks than idiosyncratic shocks. Research on the heterogeneity of the impact of natural disasters on household welfare and the economic mechanism underlying the heterogeneity is thus lacking in the existing literature.

As the majority of poor households living in developing countries are self-employed in agriculture, the literature on agricultural household models is relevant in exploring the economic mechanism underlying the heterogeneity. The classic work by Singh et al. (1986) and de Janvry et al. (1991) demonstrate that production decisions by rural households are affected by their consumption preferences when markets are incomplete. In the context of this paper, such households may attempt to smooth income *ex ante* in the expectation of natural disasters. For instance, farmers can choose crop portfolios to reduce exposure to risk (Kurosaki and Fafchamps, 2002) or allocate more of their labor to non-agricultural activities when weather risk in agricultural production is high (Ito and Kurosaki, 2009). At the same time, self-employed households can also use *ex post* measures to smooth consumption after they are hit by shocks. Such measures include savings, assets, credits, and transfers (Fafchamps, 2003; Dercon, 2005). The effectiveness of these *ex post* and *ex ante* measures against village-level shocks is not well investigated in the literature.

This paper attempts to fill these gaps in the literature by investigating the following questions: Which type of households in rural Pakistan are more vulnerable to natural disasters such as floods and droughts in terms of a decline in their consumption during such disasters and if we find heterogeneity across households in the vulnerability thus defined, what kind of microeconomic mechanism is likely to underlie the heterogeneity? In addressing these questions, we compare consumption response to village-level and idiosyncratic shocks and investigate how the two differ across different types of households, because this comparison is useful in inferring the microeconomic mechanisms underlying the heterogeneity in vulnerability. The employment of this comparison is unique to this paper and motivated by the possibility of a coexistence of risk sharing among villagers and intertemporal resource allocation using credit markets outside the village. The approach and findings of this paper thus contributes to our understanding of resilience against natural disasters in the context of economic development (Perrings, 2006).

The remainder of the paper is organized as follows. The data used in this study is described in Section 2. The empirical strategy is presented in Section 3 while the econometric results are discussed in Section 4. Section 5 concludes the paper.

2 Data

2.1 Characteristics of Pakistan's economy

Pakistan is a low-income country with a population of 174 million people in 2010, where the share of agriculture in GDP continues to be high at over 20% (Government of Pakistan, various issues). There are two main crop seasons: *Kharif* and *Rabi*,[3] whose harvest fluctuates substantially depending on the rainfall (Kurosaki, 1998), because the availability of canal irrigation water depends on fluctuating rainfall in the Himalaya and the delivery of irrigation water at the farm level is disrupted frequently due to administration problems in the irrigation system. The non-agricultural sector also depends on agriculture, including agro-industries (such as cotton-based textiles) and agro-services (such as trade of agricultural produce). The performance of Pakistan's economy, therefore, fluctuates substantially depending on the weather.

[3] The *Kharif* crop is the monsoon or autumn crop for which harvests come in September-November; rice, cotton, and maize are major *Kharif* crops. The *Rabi* crop is the dry season or spring crop for which harvests come in March-June; wheat and gram pulse are major *Rabi* crops.

The country is also characterized by spatial disparity across the four provinces comprising Pakistan and between urban and rural areas. Among the four provinces, Punjab and Sindh, which account for approximately 80% of Pakistan's total population, are regarded as economically more advanced than the other two. Between urban and rural areas, even after adjusting for differences in prices, income and expenditure levels in urban areas are much higher than in rural areas. The urban-rural disparity is largest in Sindh, where the rural regions are lagging behind in terms of income, education, health facilities, and so on, and are characterized by a few big landlords and numerous landless sharecroppers (Perera, 2003).

Recent changes in Pakistanis' average consumption, inequality, and poverty levels can be analyzed using repeated cross-section household datasets. Four rounds of nationally-representative, repeated cross-section data (PIHS/PSLM data) surveyed by the Federal Bureau of Statistics of the Government of Pakistan for 1998/99,[4] 2001/02, 2004/05, and 2005/06 revealed that the average consumption declined initially and increased in the two subsequent periods; poverty measures moved in the opposite direction; inequality decreased from 1998/99 to 2001/02, then it increased rapidly from 2001/02 to 2004/05 (Government of Pakistan, various issues). The movement of the average consumption and poverty measures (with the direction reversed) parallels with that of per-capita real GDP. The movement of inequality measures tends to be in the opposite direction of the movement of per-capita real GDP, as richer households' income is more sensitive to the macroeconomic conditions than that of poorer households in Pakistan.

2.2 PRHS panel data

In this paper, we employ micro data from the Pakistan Rural Household Survey (PRHS), which provides a unique panel dataset from Pakistan with a relatively large sample

[4] Pakistan's fiscal year as well as agricultural year begins on July 1 and ending on June 30 of the next year.

size. The survey was conducted jointly by the Pakistan Institute of Development Economics and the World Bank. The first survey (PRHS-I) was conducted in the period from September 2001 to January 2002; information was collected on agriculture-related activities for the crop seasons of *Kharif* 2000 and *Rabi* 2000/01 and that on consumption corresponding to the month preceding the survey. Approximately 2,700 rural households in all four provinces of Pakistan were included in the survey. In PRHS-I, the sample households and villages were chosen from a stratified random sample, using the villages' distance to a market as the stratification criterion. Judging from the comparison of the distribution of household consumption, assets, and demographic structure in the PRHS-I sample and their distribution in nationally-representative PIHS sample, the PRHS sample was broadly representative of each province.

The second survey (PRHS-II) was conducted three years later, from August to October 2004; information was collected on the crop seasons of *Kharif* 2003 and *Rabi* 2003/04, and on consumption in the month preceding the survey. Because of security problems and other reasons, only those sample households in two provinces of Punjab and Sindh were re-surveyed. In PRHS-I, approximately 850 sample households were surveyed in two provinces that were not covered by PRHS-II.

From the PRHS panel data, nominal consumption expenditure[5] per capita[6] in Pakistan rupees was calculated and then converted into real terms by dividing this value by the official poverty line.[7] This is known as the "welfare ratio" and is denoted as c_{it} below,

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[5] Since numerous farm households in Pakistan are subsistence-oriented and numerous rural laborer households are occasionally paid in kind, the value of the non-cash transactions were carefully imputed using village-level prices in the calculation of consumption expenditure, following the standard in the literature (Deaton and Zaidi, 2002).

[6] To be precise, "per capita" implies "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 the weight of 0.8.

[7] 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 comparisons. The official poverty line was converted into the poverty line for each PRHS by the author using regional price indices.

where subscript *i* refers to individual *i* and *t* refers to the survey year.

A balanced panel of 1,609 households (929 in Punjab and 680 in Sindh) has been thus compiled, for which complete consumption information was available in both surveys. The sample households came from 48 sample villages in Punjab and 46 sample villages in Sindh. In PRHS-I, the number of sample households in Punjab and Sindh with complete consumption information was 1,874, thereby implying an attrition rate of 14%. Although the attrition was not purely random (initially poorer and more mobile households tended to leave the sample more frequently than other households), the correlation of attrition and household characteristics was not statistically significant and droughts and floods (see below for their definitions) were not associated with higher attrition rate.[8] Considering that the focus of this paper is on the impact of natural disasters on welfare changes, we conclude that there is unlikely to be significant bias in our estimates. A reservation to this conclusion should be added, however, considering the incomplete availability of village-level shocks in PRHS-II due to the village-level attrition. We can conjecture that the four attriting villages were hit by some sort of shocks and cannot disregard the possibility that such shocks include droughts or floods. In interpreting our quantitative results, this limit in external validity and generalizability should be borne in mind.

Table 1 presents average c_{it}, poverty headcount ratios, and Atkinson inequality measures based on the PRHS panel data. Since there is a socioeconomic gap and a difference in historical legacies between the northern and southern parts of Punjab, we divide Punjab

[8] Using the information in PRHS-I household data and PRHS-II village-level data, three types of analysis were implemented to investigate the potential attrition bias. First, each of household characteristics in the PRHS-I data was compared between panel and attrition households (bivariate comparison). Second, a multiple regression model was estimated with the household-level attrition dummy as the dependent variable. Third, log consumption per capita from the first round of survey was regressed on the baseline characteristics of households, an attrition dummy, and the attrition dummy interacted with the other explanatory variables. The attrition dummy and the interaction terms were jointly insignificant. Detailed results are available on request from the author.

into two portions.[9] The changes between PRHS-I (2001) and PRHS-II (2004) are similar to the changes between PIHS 2001/02 and PSLM 2004/05, which are nationally representative. The average consumption increased substantially from 2001 to 2004. The increase was slightly larger in Sindh than in northern and southern Punjab, thereby reducing the gap between the two provinces. In spite of this, the ranking of average economic well-being among the three regions (northern Punjab at the top, Sindh at the bottom and southern Punjab in between) remained the same in 2004.

2.3 Welfare changes at the household level and economic shocks

The increase in the average consumption shown in Table 1 was not shared equally among all PRHS households. In order to utilize the advantage of panel data, Table 2 reports the distribution of welfare changes at the household level, measured by the change in log consumption per capita (*dlnc*). Among the full sample of 1,609 panel households, the average of *dlnc* was 0.218, indicating an increase of 24.3% in real consumption over the three year period. However, 36.3% of individuals suffered from a decline in their welfare levels (i.e., *dlnc* was negative). Thus, the aggregate figure conceals the fact that certain households suffered from a severe decline in their welfare during the survey period.

Idiosyncratic and village-level negative shocks may have been responsible for the consumption decline of certain households when the nation experienced a consumption increase on average. As an indicator of idiosyncratic shocks, we constructed a dummy variable from the PRHS panel data for households whose members experienced a severe health shock due to injury or sickness that resulted in treatment in medical institutions between PRHS-I and PRHS-II. Approximately 7% of the sample households experienced

[9] Among 35 districts in Punjab, 6 districts were surveyed in PRHS. Among these six, 3 districts of Attock, Faisalabad, and Hafizabad are classified as "northern Punjab" while 3 districts of Bahawalpur, Muzaffargarh, and Vehari are classified as "southern Punjab" in this paper. The division is based on the ongoing discussion in Pakistan's parliament to divide the province of Punjab. Moreover, from among 22 districts in Sindh, the PRHS data include 4 districts of Badin, Larkana, Mirpur Khas, and Nawabshah.

such shocks. There was no statistically significant difference in the mean of the health shock variable across three regions.

Further, with regard to village-level shocks, we compiled variables containing the information on drought and flood shocks. In PRHS-II, the information was collected from village elders using a community questionnaire. In the survey, the negative impact due to natural disasters was assessed on a five-point scale: 0 (“No effect”: no report for crop damage in the village), 1 (“Little effect”: yield loss up to 10% in the village), 2 (“Moderate”: 10-25% loss in the village), 3 (“Severe”: 25-50% loss in the village), and 4 (“Disaster”: over 50% loss in the village). Eight cropping seasons up to the survey reference period (i.e., from *Kharif* 2000 to *Rabi* 2003/04) were covered.

Table 3 presents the incidence of these disasters in 2002/03 and 2003/04. It is evident that droughts are more common than floods—they occurred in all three regions with similar frequency. On the other hand, flood damage was not reported from northern Punjab, and only infrequently from southern Punjab. It may appear that the variation in drought and flood damage reported at the village level is in effect more aggregate, with little effective variation across villages within a region. In order to investigate whether this applies to our data, we examined the spatial correlations of drought and flood variables. For example, only 17.3% (21.3%) of the variation of the drought (flood) damage variable was explained by variation across the three regions and the rest (82.7% of the drought variation and 78.7% of the flood variation) was within-region, between-village variation. The latter variation will be utilized in identifying the effects of village-level aggregate shocks on household welfare. As the sample size is small in our case, in the regression, the information in Table 3 will be aggregated into one variable representing drought shocks and another variable representing flood shocks in the regression analysis (see Subsection 4.1).

Back to Table 2, we compare the distribution of *dlnc* for subsets of households distinguished by the village-level and household-level shocks. To sharply identify the impact of shocks on welfare changes, we now redefine the consumption by excluding durables, house rent, and medical expenditures, and use a subset of sample households excluding households that experienced a drastic change in their demographic structure, outlier households in the distribution of *dlnc*, and observations for which the village-level shock information was missing.[10] This reduced the sample size from 1,609 (Table 1) to 1,363.

As expected, both the average *dlnc* and the percentage of individuals whose *dlnc* was positive are lower when the village was hit by droughts/floods or the household suffered from health shocks. It appears that idiosyncratic and village-level negative shocks were responsible for the consumption decline of certain households when the economy grew on average. The bivariate comparison, however, suggests that the statistical significance of the difference was not particularly high for floods and health shocks. Furthermore, a confounding factor is region-specific trends—both the average *dlnc* and the percentage of individuals whose *dlnc* was positive are significantly different across three regions. We need to control for region-specific trends and other determinants of *dlnc* to identify the impact of natural disasters on welfare changes. In the next section, we propose an empirical strategy for this.

3 Empirical Strategy

3.1 Empirical model

To exploit the benefit of the panel data, we employ the first difference in log consumption ($\Delta \ln c_i = \ln c_{i,2004} - \ln c_{i,2001}$) as the dependent variable so that unobservable and

[10] The reason for redefining consumption in this way is that we follow the standard way of defining aggregate consumption for welfare analysis in poor countries, recommended by Deaton and Zaidi (2002). They argue that medical expenditures are "regrettable necessities" that yield no welfare in their own right, but that have to be purchased in order to earn income (p.20). The reason for excluding households with a large change in demographic structure is that due to their demographical changes, *dlnc* (the change in per-capita consumption expenditure) may be a poor measure of the welfare change for such households because their preferences were likely to have changed substantially. In excluding outliers in terms of the distribution of *dlnc*, we used the range of (1%, 99%) to include the sample for analyses, but the results were qualitatively the same when the range was changed, as discussed in the robustness check.

time-invariant characteristics of a household that affect the consumption level are controlled cleanly. We first regress the consumption change on initial household characteristics (taken from the PRHS-I data) and variables that capture shocks. Since there are only two periods in our panel dataset, the empirical model is given by the following regression model for household i:

$$\Delta \ln c_i = X_{1i}b_0 + b_{1,0}Z_{1v} + b_{2,0}Z_{2v} + b_{3,0}Z_{3i} + \varepsilon_i, \quad (1)$$

where X_{1i} is a vector of household characteristics in PRHS-I such as physical assets owned by the household, income sources, credit access, education level of the household head, and demographic composition; Z_{1v} is a measure of village-level drought shocks that occurred between PRHS-I and PRHS-II in village v where household i lives; Z_{2v} is a similar measure of village-level flood shocks; Z_{3i} is the idiosyncratic health shock already discussed; b_0 is a vector of parameters to be estimated; $b_{1,0}$, $b_{2,0}$, and $b_{3,0}$ are parameters to be estimated; and ε_i is a zero mean error term. X_{1i} also includes the intercept term and region dummies.

Since there was an overall growth in the economy in our dataset, by investigating parameters included in b_0, we can infer which households were more able to keep up with the national growth trend than other households. Parameters $b_{1,0}$, $b_{2,0}$, and $b_{3,0}$ show the average impact of village-level and idiosyncratic shocks on consumption growth. Given bivariate relations shown in Table 2, we expect these parameters to be negative.

We then extend the model in equation (1) allowing the impact of shocks on consumption growth to differ depending on household characteristics:

$$\Delta \ln c_i = X_{1i}b_0 + Z_{1v}X_{2i}b_1 + Z_{2v}X_{2i}b_2 + Z_{3i}X_{2i}b_3 + \varepsilon_i, \quad (2)$$

where X_{2i} is a subset of X_{1i} used for interaction terms,[11] while b_1, b_2, and b_3 are vectors of parameters to be estimated. When region dummies are included in X_{2i}, the difference in vulnerability across regions can be examined. Moreover, when households' initial attributes

[11] The interaction terms of aggregate shocks and initial characteristics are often employed in macroeconomic studies on the impact of natural disasters on economic growth. See Cavallo and Noy (2010).

are included in X_{2i}, vector b_1 indicates which household attributes are associated with a larger or smaller decline in consumption if the village is hit by droughts. Similarly, vector b_2 identifies the households that are more likely to reduce consumption when the village is hit by floods. Thus, parameters in b_1 and b_2 are of main interest of this paper. Furthermore, parameters in b_3 in equation (2) show which households have to cut their consumption substantially when they are hit by negative health shocks.

3.2 Inference on the economic mechanisms underlying the heterogeneity

Since equation (1) is a restricted version of equation (2), we can test whether the heterogeneity is statistically significant using an *F*-test for the null hypothesis that all coefficients in b_1, b_2, and b_3 are zero except for $b_{1,0}$, $b_{2,0}$, and $b_{3,0}$, which are associated with the constant in vector X_{2i}. If this null is rejected in favor of heterogeneity in consumption response to shocks, we examine the coefficients $b_{1,k}$, $b_{2,k}$, and $b_{3,k}$, which are associated with variable X_{2ki} in vector X_{2i}. Depending on the nature of X_{2ki}, several patterns of their signs are predicted by the standard theory of household behavior under uncertainty. We briefly discuss them in two parts: *ex ante* mechanisms and *ex post* mechanisms.

First, if variable X_{2ki} is associated with *ex ante* measures of income diversification, its coefficients are likely to positive, since the variable mitigates the ill effect of shocks. We can list three subcases that have mutually exclusive predictions. As the first subcase, if higher X_{2ki} implies that households can more easily diversify the drought risk, say through a deliberate choice of crop portfolio (Kurosaki and Fafchamps, 2002), we expect $b_{1,k} > 0$, $b_{2,k} = 0$, and $b_{3,k} = 0$, because such farmers' crop income loss due to droughts is mitigated.[12] As another subcase, if higher X_{2ki} implies that households can more easily diversify income sources, say through non-agricultural labor supply (Ito and Kurosaki, 2009) and the health shock occurs on

[12] Because of the endogeneity problem, we do not include a direct measure of crop choices in vector X_{2i}. Instead, we focus on exogenous factors in X_{2i} that can affect the household's ability to diversify crop portfolio.

working members, we expect $b_{1,k} > 0$, $b_{2,k} > 0$, and $b_{3,k} < 0$, because such households' income is more resilient against agricultural shocks while more vulnerable to health shocks. Although not strictly an *ex ante* measure, any factor that reduces the transmission of the shocks to income reduction is analyzed in a similar way. As the third subcase, regarding floods, if X_{2ki} is associated with higher political connections to affect the control on dykes and waterworks, the income loss due to floods for households with higher X_{2ki} may be smaller. Then we expect $b_{1,k} = 0$, $b_{2,k} > 0$, and $b_{3,k} = 0$.[13]

Second, if variable X_{2ki} is associated with *ex post* measures of higher ability to smooth consumption, its coefficients are likely to be positive. We can list three subcases that have mutually exclusive predictions here as well. If households smooth consumption only through credit markets whose lending conditions are not affected by village-level shocks and X_{2ki} enhances the household ability to borrow, we expect $b_{1,k} > 0$, $b_{2,k} > 0$, and $b_{3,k} > 0$. On the other hand, if households smooth consumption only through village-level risk sharing, all households in the risk-sharing network have homogeneous risk preference, the extent of risk sharing is partial, and X_{2ki} enhances the household ability to share risk with others, we expect $b_{1,k} = b_{2,k} = 0$ and $b_{3,k} > 0$. This is because village-level shocks (which cannot be insured through village-level risk-sharing) affect consumption of risk-sharing network members by the same proportion regardless of the efficiency level in sharing idiosyncratic shocks. Finally, if households do not use outside credit markets but are based on a full risk-sharing network at the village level to smooth consumption, households in the network have heterogeneous risk preferences, and X_{2ki} reduces the household capacity to bear risk, we expect $b_{1,k} > 0$, $b_{2,k} > 0$, and $b_{3,k} = 0$. This is because under full risk-sharing among heterogeneously risk-averse households, households with higher ability to bear risk take more of the burden of

[13] Unfortunately, we do not have a direct measure of political connections in our dataset. The possibility of this mechanism will be taken care of when we discuss the regression results for variables that could be indirectly related with political connections.

village-level shocks than other households do.[14]

These six subcases, however, do not cover all parameter combinations and are valid only when several assumptions are satisfied (they are only necessary conditions). Therefore, the main empirical strategy to infer the economic mechanisms underlying the heterogeneity is to carefully examine the signs of $b_{1,k}$, $b_{2,k}$, and $b_{3,k}$, considering the nature of variable X_{2ki} and the possibility of both *ex ante* and ex *post* mechanisms. Since the six subcases suggest that it is informative to compare the consumption response to village-level and idiosyncratic shocks, we include the term involving Z_{3i} in our empirical models. As the main interest of this paper is on the impact of village-level shocks, we will discuss on coefficients on health shocks only to the extent that the discussion is useful in distinguishing the underlying mechanisms. Econometrically speaking, if Z_{3i} is orthogonal to Z_{1v} and Z_{2v}, the entire expression $Z_{3i}X_{2i}b_2$ in equation (2) can be excluded and merged into ε_i without affecting our ability to obtain unbiased estimates for b_1 and b_2. This is indeed the case as shown below.[15]

4 Sensitivity of Consumption Changes to Village-level Shocks

4.1 Empirical variables

As controls for household characteristics that determine consumption growth (vector X_{1i} in equations (1) and (2)), we follow the standard literature on the determinants of welfare in developing countries (for example, Glewwe, 1991) and include variables such as agricultural production assets owned by the household (farmland, draft animals, and farm machinery/equipment), other household assets (milk animals, sheep and goats, durable consumption goods, transportation equipment, house buildings, etc.), income sources (number

[14] In other words, households with higher ability to bear risk will serve as an insurer in the village economy against village-level shocks in return for implicit payment. See Kurosaki (2001) for an example of such mathematical models.

[15] Because of this orthogonality, our estimates for b_1 and b_2 are free from (potentially) omitted variable bias due to the non-inclusion of other household-level idiosyncratic shocks such as death, marriage, changes in migration environment, or idiosyncratic components of crop shocks, on which our dataset does not contain useful information.

of male working members engaged in permanent or casual non-farm work[16]), credit access, distance to the marketplace, education level of the household head, and demographic composition (number of household members, female ratio among them, and dependency ratio). We identify a household as credit constrained either if it needed to borrow and applied for a loan but was rejected, or, if it needed to borrow but did not apply for the loan due to the distance to credit institutions, no guarantee available, no collateral, or excessive procedures.

After attempting several methods of aggregating the village-level shock variables presented in Table 3, we chose the default definition of two variables for drought and flood in the following way. We aggregated shocks in four cropping seasons in two agricultural years of 2002/03 and 2003/04, and then normalized them between zero and one by dividing by 16 (the max of the scores shown in Table 3). The robustness of our results with respect to this definition will be investigated below. Since the PRHS-II consumption data were collected in August-October 2004, the agricultural output in 2002/03 and 2003/04 should have had the most direct effect on household consumption. Production shocks that occurred before these two years may have affected the PRHS-I consumption level. For this reason, we use the shocks in the last two years as village-level shocks that are exogenous to initial consumption.

Table 4 presents the summary statistics for explanatory variables used in the regression analysis. They are weighted by the household size in order to obtain individual-level means and standard deviations, since the regression analysis is conducted in order to gauge individual welfare.

4.2 Average impact of shocks and its regional heterogeneity

In Table 5, we show the estimation results of equation (1) (specification (i) in the

[16] Because of a social norm of women exclusion called *Purdah*, women in rural Pakistan seldom work off the farm for wages or salary, and even when they do, it is difficult to obtain precise information in a survey due to the norm. For this reason, these variables are defined on male labor.

table) and equation (2) when interaction terms are with region dummies (specification (ii)). Among household characteristics X_{1i}, seven variables have statistically significant coefficients in both specifications: the size of owned land (negative), the number of male household members who were employed permanently in regular non-farm jobs (positive), the distance to marketplace (negative), household head's age (positive), household head's years of schooling (positive), dependency ratio (positive), and the size of household (negative). The finding that households with larger landholding were lagging behind in consumption growth suggests that growth from 2001 to 2004 was based on non-agricultural sectors. The coefficients on non-farm permanent employment jobs, the market distance, and household head's education are also consistent with this interpretation, as the gain from economic growth based on non-agricultural sectors is more easily captured by more educated households living closer to the marketplace with more members working in non-agriculture. The positive coefficient on non-farm permanent employment jobs may also indicate a life-cycle improvement in earnings associated with non-farm permanent jobs (e.g., regular promotion). The finding that households with a greater number of 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 older by three years. The proxy variables for credit constraints have a positive sign, as expected from the theoretical model (Deaton, 1991); however, the coefficients were statistically insignificant. These patterns are robustly found under different specifications of equation (2). Therefore, parameter estimates for b_0 are not reported in the following table in order to save space.

With regard to coefficients on village-level production shocks, the coefficients on natural disasters are all negative in specification (i). The absolute value of the coefficient on floods is especially large, indicating that households had to reduce consumption by 42% (1 – exp(-0.5508) = 0.4235) when their village was hit by floods that destroyed over 50% of crops in all four seasons in the village. This implies a substantial decline in welfare. On the other hand, the coefficient on drought shocks is statistically insignificant and that on health shocks is only marginally significant. The insignificance of drought shocks may appear surprising given the bivariate comparison shown in Table 2. The inclusion of region fixed effects drives the result in Table 5—the relatively inferior growth trend in southern Punjab absorbed some of negative impacts of droughts shown in Table 2, resulting in an insignificant effect of drought shocks in Table 5.

The contrast between droughts/health shocks and floods could be understood by the insurability of shocks within a region. Theoretically, it is easy to insure health shocks within a village since they are idiosyncratic. Drought shocks are more aggregate than health shocks; however, because droughts occur frequently in rural Pakistan, villagers may have established an institution to insure against them across villages within a region. On the other hand, it is difficult to insure against floods because they occur infrequently and they disrupt across-village transportation and communication. With disrupted transportation and communication, the institutional arrangement could have become less effective. Regarding the contrast between droughts and floods, another possibility is that droughts' onset is more gradual than floods so that households are more able to cope with droughts. These are speculations, however, for which rigorous testing is left for further research.

In order to examine whether there are any regional differences in impacts of natural disasters, specification (ii) in Table 5 permits the coefficient on Z to differ across the three regions. Since no incidence of flood was reported from northern Punjab, the interaction terms that include floods are only for southern Punjab and Sindh. With regard to the effect of floods, it remains highly negative and significant on both regions. For droughts and health shocks, four out of six coefficients were statistically insignificant, one was significantly positive, and the other was significantly negative. We do not have good reason to explain the positive coefficient found for droughts in southern Punjab. Furthermore, the null hypothesis that the impact of shocks is the same in all regions is not rejected at the 10% level. For this reason, the interaction terms with region dummies are not included in the following specifications.

4.3 Heterogeneous impact among households

In order to further examine the heterogeneity in the marginal impact of natural disasters, household-level characteristics were interacted with shocks (Table 6). From among the fourteen household-level variables in X_{1i}, six are chosen to make interaction terms with shock variables (vector X_{2i} in equation (2)). Five of them (size of land holdings, number of household members employed in permanent non-agricultural jobs, age of the household head, education level of the head, and dependency ratio) are those variables in X_{1i} in equation (1) that have robustly significant coefficients. The other (the dummy for credit constraint in the formal sector) is included because it is a direct measure of credit access. Other interaction terms were tried but found with insignificant coefficients. Therefore, to improve the estimation efficiency given the small size of the sample, we limit the variables in X_{2i} to these six variables. The interaction term using the number of household members permanently employed off the farm (*nfe_perm*) may capture *ex ante* impact of labor supply diversification. Furthermore, the interaction term between drought and the landholding size may capture *ex ante* impact of crop diversification. All of these interaction terms are also meant to capture *ex post* consumption smoothing mechanisms. In specification "default," the regression results using the same definition of natural disaster shocks as in Table 5 are reported, while in specification "alternative," the village-level shock variables are defined differently.[17]

As shown in Table 6, the null hypothesis that the impact of shocks is the same across

[17] In the alternative definition of village-level shocks, disaster variables correspond to the larger disaster of the last two years instead of their averages, normalized between 0 and 1, since it is possible that only major disasters matter.

different household characteristics is rejected at the 1% level in both specifications. Therefore, the heterogeneity in consumption response to shocks is statistically significant.

Examining individual coefficients on the interaction terms in Table 6, the following pattern is suggested. First, households with more dependent members were more capable of isolating their consumption from a drought-driven income decline. Second, the ill effects of flooding are mitigated if a household is more landed or the household head is younger. Third, with regard to the impact of idiosyncratic health shocks on consumption, access to formal credit helps to mitigate the ill impact.

The heterogeneity pattern is informative in terms of theoretical predictions discussed in Subsection 3.2. The interaction term of landholding with flood shocks has a significantly positive coefficient while its interaction terms with droughts and health shocks have insignificant coefficients. Several explanations can be offered. Based on the mechanism of unequal access to credit markets, the significantly positive coefficient on the interaction term with floods imply that the amount of landholding has the effect of reducing household vulnerability to floods by improving their ability in intertemporal resource allocation. Since the land sales market is thin in rural Pakistan, it is likely that this ability is due to the collateral and social value of land (Hirashima, 2008). Although statistically insignificant, positive coefficients on the interaction term with droughts gives weak support to this interpretation. Another possibility is that landholding mitigates the transmission of flood shocks to household income. The direct route does not support this interpretation since the total income of more landed households must be affected proportionally more by floods as compared with less landed households. The indirect route may support this interpretation since landholding is likely to be associated with higher political connections to affect the control on dykes and waterworks, so that more landed households' income loss due to floods become smaller. The interpretation based on full risk-sharing among heterogeneous households does not hold here since more landed households are more able to bear risk so that we expect a negative coefficient on the interaction term of floods and landholding.

Next, the access to formal credit, by definition, improves the ability of households in intertemporal resource allocation. The significantly negative coefficient on the interaction term of credit access and health shocks supports this interpretation. Nevertheless, coefficients on the interaction terms of credit access and village-level shocks change their signs depending on specification and all are statistically insignificant. One interpretation could be that formal credit access may not be effective in coping with village-level shocks since such shocks increase the local demand for formal credit, thereby violating the assumption for the first subcase of *ex post* mechanisms that lending conditions in the credit market are not affected by village-level shocks. Another possibility is that the access to formal credit improves the household ability to share idiosyncratic risk with others, as argued in the second subcase among *ex post* mechanisms with partial risk sharing. We can deny the possibility that the formal credit access is associated with some factor that mitigates the transmission of health shocks to household income because there was no use of health insurance among the sample households.

In contrast, households headed by elder household heads are subject to a larger consumption decline when hit by floods (and marginally by droughts as well), while the age of heads does not affect the impact of health shocks. From the viewpoint of household ability in using credit, this appears to be a puzzle. Our speculation is that the third subcase among *ex post* mechanism in Subsection 3.2 based on the theory of full risk sharing among heterogeneously risk-averse households may apply to the data. Households with elder heads are able to bear more risk than other households; thus, it is more efficient for them to bear greater aggregate risk (in return for higher expected values of transfers from the risk-sharing network). The observed pattern is difficult to explain by the argument based on heterogeneous impact of exogenous shocks on household transient income, since it is natural to expect that the household income of those with older household heads is less affected by droughts and floods (then the interaction term should have a positive coefficient).

Significantly positive coefficients on the interaction terms of droughts and the dependency ratio are interpreted in a way similar to the interaction terms of floods and the head's age. Households with a smaller number of working members are less able to bear more risk than other households; thus, it is more efficient for others to bear greater aggregate risk. The negative and sometimes statistically significant coefficients on interaction terms of the dependency ratio with flood shocks cast a doubt against this interpretation, however. Therefore, the interpretation for the interaction terms involving the dependency ratio is left for further research.

All of the interaction terms using the number of household members permanently employed off the farm have insignificant coefficients. This suggests that the *ex ante* impact of labor supply diversification in reducing the ill effects of natural disasters is limited in the study region.

4.4 Sensitivity of the heterogeneous impact with respect to other specifications

The results in Tables 5-6 were found to be robust to various alterations.[18] We give the summary of these sensitivity checks in Appendix Table, focusing on the heterogeneous impact among households.

First, the main results reported in this paper were not affected by the particular way we aggregated the information in Table 3 into two variables of village-level drought and flood shocks. Second, the specification without health shocks yielded estimates for b_1 and b_2 highly similar to those reported in Table 6. In other words, our assumption of the idiosyncratic nature

[18] Detailed results of these sensitivity checks are available on request from the author.

of the health shock variable was found to be valid. Third, the extension of the regression model to allow region-specific slopes of household characteristics X_{1i} in equation (2) did not affect our estimates for b_1 and b_2. Fourth, to examine whether the regression results are sensitive to a particular choice of the regression subsample, we re-estimated the model using the larger subsample, without throwing away outlier observations in terms of the distribution of per-capita consumption. The results were again similar to those reported in Table 6. Fifth, as several households in our dataset are subsistence-oriented farmers (Singh et al., 1986; de Janvry et al., 1991), the way we imputed the value of unpaid food consumption (mostly the consumption of self-produced foods) may have affected our results. To examine this possibility, we re-calculated the imputed value under the assumption that the shadow prices of unpaid foods consumed by the household are 20% lower than the village prices. The results shown in Table 6 remain robust with this type of alteration. It is not likely, therefore, that the exact way how we imputed the self-produced foods consumed by the household brought bias in our main results. Finally, we re-estimated the regression models by replacing the total consumption by food consumption. The regression results were again highly similar to those reported in Table 6.

5 Conclusion

This paper investigated which households in rural Pakistan were vulnerable to natural disasters in terms of a decline in their consumption when their village was hit by disasters such as floods and droughts. The regression results associating observed changes in consumption to household characteristics and village-level disaster variables indicated the following results. The sensitivity of consumption changes to village-level shocks differentiated by household characteristics is different from that to idiosyncratic health shocks differentiated by similar characteristics. It was found that more landed households were less vulnerable to flood shocks while households with greater access to formal financial institutions were less vulnerable to idiosyncratic health shocks. On the other hand, households in which the household head is elderly bore a larger burden of village-level shocks, while they were not vulnerable to idiosyncratic health shocks. It is possible that these patterns were due to the coexistence of unequal access to credit markets and risk sharing among heterogeneous households in terms of risk tolerance. We were not able to find a significant impact of *ex ante* labor diversification on mitigating the ill effects of natural disasters.

From anthropology literature on the rural society in Pakistan, it can be speculated that landlord-based networks of patron-client relationships are a possible mechanism that enable intra-region and inter-village risk sharing. Since such networks are strongest in rural Sindh, this interpretation appears consistent with the finding that Sindh villagers were protected against health and drought shocks but they suffered from the lowest average consumption level and their consumption dropped substantially when their villages were hit by floods. This interpretation also appears consistent with the finding that northern Punjab villagers enjoyed the highest average consumption level that was mostly self-insured. As this interpretation is more a speculation than an evidence-based result, clean identification of the actual mechanism is left for further research.

The findings of this paper have several policy implications regarding household-level resilience against village-level natural disasters in developing countries. First, the pattern of welfare declines is heterogeneous so that minute targeting is required. It may be the case that an intervention to cope with natural disasters without such concern is not effective towards some households in the affected villages. Second, the contrast found in this paper with regard to the impact of droughts and floods appears to indicate that whether or not a disaster damages physical infrastructure makes a substantial difference in terms of resiliency. Households have more difficulty in coping with floods than droughts since floods disrupt transport and communication. Third, improving intertemporal smoothing ability of households through developing assets and credit markets is key to mitigating the ill effects of floods. Investment in infrastructure such as transport and communication could contribute to higher resilience against natural disasters through both the second and third (through the improvement in the level of efficiency of risk sharing or facilitating credit transactions in wider areas) routes.

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

	PRHS-I (2001)	PRHS-II (2004)
1. Average welfare ratio		
Punjab and Sindh pooled (rural only)	1.465	1.846
	(0.029)	(0.038)
Northern Punjab	1.848	2.190
	(0.064)	(0.070)
Southern Punjab	1.546	1.886
	(0.065)	(0.099)
Sindh	1.175	1.617
	(0.028)	(0.043)
2. Poverty headcount ratio		
Punjab and Sindh pooled (rural only)	0.372	0.259
	(0.014)	(0.013)
Northern Punjab	0.196	0.154
	(0.020)	(0.019)
Southern Punjab	0.361	0.267
	(0.026)	(0.024)
Sindh	0.490	0.318
	(0.022)	(0.021)
3. Atkinson inequality measure		
Punjab and Sindh pooled (rural only)	0.359	0.425
	(0.012)	(0.013)
Northern Punjab	0.336	0.394
	(0.019)	(0.022)
Southern Punjab	0.359	0.461
	(0.027)	(0.032)
Sindh	0.305	0.392
	(0.015)	(0.016)

Notes: The number of observations (NOB) is 1,609. The inequality aversion parameter for Atkinson measures is set at 3. Standard errors are reported in parenthesis. Statistics are weighted in order to make figures representative of individual-level summary statistics.

Source: Calculated by the author from PRHS panel data (same for the following tables).

Table 2. Household-level welfare changes in Pakistan from 2001 to 2004

	Distribution of *dlnc* (change in log consumption per capita)			
	NOB	Mean	Std.Dev.	% *dlnc*>0
All sample, all consumption expenditure items included				
Punjab and Sindh pooled (rural only)	1,609	0.218	0.665	63.7
Subsample for regression analysis, adjusted consumption*				
Punjab and Sindh pooled (rural only)	1,363	0.189	0.617	62.6
By regions#		*p*=0.0000		*p*=0.0018
Northern Punjab	440	0.174	0.551	64.8
Southern Punjab	364	0.082	0.591	54.8
Sindh	559	0.263	0.663	65.7
By village-level drought shocks#		*p*=0.0000		*p*=0.0072
Any shock in the last 2 years	857	0.126	0.589	59.9
No shock	506	0.297	0.648	67.1
By village-level flood shocks#		*p*=0.114		*p*=0.3006
Any shock in the last 2 years	295	0.141	0.622	60.1
No shock	1,068	0.204	0.615	63.3
By household-level health shocks#		*p*=0.0971		*p*=0.1874
Yes	78	0.088	0.509	56.3
No	1,285	0.197	0.624	63.0

Notes: % *dlnc*>0, Mean, and Std.Dev. (standard deviation) are weighted by the household size in PRHS-I in order to obtain individual-level summary statistics.

* The subsample used in the regression analyses is those households whose welfare ratios and its log changes were in the range of (1%, 99%) of the sample distribution and whose membership changed by less than four persons during the two surveys. *dlnc* is re-defined as "Log difference of the welfare ratio between PRHS-I and PRHS-II (consumption excluding durables, house rent, and medical expenditures)".

For each classification, the probability value of a chi-squared test for the null hypothesis that "% *dlnc*>0 is the same" or "Mean of *dlnc* is the same" is reported.

Table 3. Incidence of village-level production shocks in Pakistan

	Distribution of damage index* in *Rabi* season (%)					Distribution of damage index* in *Kharif* season (%)				
	0	1	2	3	4	0	1	2	3	4
Drought in the last year (Kharif 2003 and Rabi 2003/04)										
N. Punjab	47.1	7.1	9.5	36.3	0.0	47.9	7.1	12.9	32.2	0.0
S. Punjab	0.0	34.1	41.4	24.4	0.0	4.8	24.9	45.3	12.9	12.1
Sindh	61.7	4.4	10.3	15.6	8.2	81.5	5.4	3.7	2.9	6.5
Drought in the year before the last year (Kharif 2002 and Rabi 2002/03)										
N. Punjab	54.4	7.1	6.4	32.2	0.0	50.8	7.1	3.0	35.7	3.3
S. Punjab	8.7	37.6	16.4	37.3	0.0	8.5	30.2	56.3	5.1	0.0
Sindh	84.0	0.0	4.8	7.5	3.7	76.7	6.7	6.6	4.1	5.9
Flood in the last year (Kharif 2003 and Rabi 2003/04)										
N. Punjab	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
S. Punjab	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Sindh	94.3	0.0	0.0	0.0	5.7	72.1	5.7	4.0	3.9	14.2
Flood in the year before the last year (Kharif 2002 and Rabi 2002/03)										
N. Punjab	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
S. Punjab	100.0	0.0	0.0	0.0	0.0	90.7	4.8	0.0	4.5	0.0
Sindh	69.1	8.0	4.5	6.5	11.9	84.9	0.0	2.8	2.4	9.9

Note: NOB=1,609. * The index takes 0 ("No effect": no report for crop damage), 1 ("Little effect": yield loss up to 10%), 2 ("Moderate": 10-25% loss), 3 ("Severe": 25-50% loss), and 4 ("Disaster": over 50% loss). Since all of them are mutually exclusive, the sum of the percentage is 100.0.

Table 4. Summary statistics of explanatory variables used in the regression analysis

Variable	Definition	Mean	Std.Dev.
Initial household characteristics (*X* in equations (1) and (2)):			
landacre	Size of farmland owned by the household (acres).	5.512	12.840
farm_asst	Value of farm production assets (draft animals, farm machinery such as tubewell, tractor, etc., and farm equipment such as plow, bullock cart, etc.) owned by the household (Rs.10,000).	1.907	6.607
hh_asst	Value of household assets (milk animals, sheep and goats, durable consumption goods, transportation equipment, house buildings, etc.) owned by the household (Rs.10,000).	4.077	6.398
nfe_perm	Number of male household members who were employed permanently by the private sector, government, or police.	0.242	0.563
nfe_casl	Number of male household members who were employed in non-farm activities on daily or contract basis.	0.416	0.735
cc_fml	Dummy for a household that was constrained to the formal credit access.#	0.665	dummy
cc_inf	Dummy for a household that was constrained to the informal credit access.#	0.103	dummy
mandy	Distance to the nearest marketplace (km).	11.478	8.959
head_age	Age of household head (years).	47.96	14.35
head_sch	Education level of household head (completed years of schooling).	2.938	3.970
head_fem	Dummy for a female-headed household.	0.018	dummy
femratio	The ratio of females in the household size.	0.482	0.144
depratio	The ratio of dependent members (aged <15 and >60) in the household size.	0.471	0.189
popwt1	Household size (Nos.).	8.874	4.410
Measures of shocks (*Z* in equations (1) and (2)):			
drought	Index variable* for crop damage due to drought in Rabi 04, Kharif 03, Rabi 03, and Kharif 02.	0.288	0.283
flood	Index variable* for crop damage due to flood in Rabi 04, Kharif 03, Rabi 03, and Kharif 02.	0.072	0.159
health_shock	Dummy variable for the household whose members experienced a severe health shock during the two survey periods resulting in medical treatment.	0.070	dummy

Notes: (1) The subsample used in the regression analyses is those households whose welfare ratios and its log changes were in the range of (1%, 99%) of the sample distribution, whose membership changed by less than four persons during the two surveys and whose village-level shock information was available. Due to this selection, the number of households in this table is at most 1,363 (1,359 for cc_fml and cc_inf, and 1,310 for head_sch), against 1,609 in Table 1.
(2) Means and standard deviations (Std.Dev.) are weighted by the household size in PRHS-I.
(3) All of the initial household characteristics are taken from the PRHS-I dataset.
Households were regarded as constrained if they needed to borrow from the formal (informal) sector and applied for a loan but rejected; or, if they needed to borrow from the formal (informal) sector but did not apply for the loan because the credit institutions are too far away, there is no guarantee available, no collateral, excessive procedures, etc. The corresponding period for formal loans is “ever until 2000/01” while that for informal loans is “during 2000/01.”
* The sum of index variables for the four seasons in Table 3 divided by 16 (minimum=0, maximum=1).

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

	Dependent variable: *dlnc* (change in log consumption)					
	(i) Without interaction terms			(ii) With interaction terms with region dummies		
Explanatory variables	Coef.		(S.E.)	Coef.		(S.E.)
Region fixed effects						
intercept	0.0389		(0.1302)	0.0686		(0.1318)
South.Punjab	-0.0563		(0.0530)	-0.2379	**	(0.0991)
Sindh	0.2471	***	(0.0798)	0.2376	**	(0.0926)
Household characteristics						
landacre	-0.0053	**	(0.0025)	-0.0051	**	(0.0024)
farm_asst	0.0007		(0.0030)	0.0004		(0.0029)
hh_asst	-0.0011		(0.0017)	-0.0011		(0.0016)
nfe_perm	0.0640	*	(0.0331)	0.0638	*	(0.0331)
nfe_casl	0.0103		(0.0280)	0.0111		(0.0282)
cc_fml	0.0258		(0.0368)	0.0218		(0.0366)
cc_inf	0.0798		(0.0609)	0.0839		(0.0618)
mandy	-0.0047	*	(0.0028)	-0.0057	**	(0.0027)
head_age	0.0027	*	(0.0014)	0.0026	*	(0.0014)
head_sch	0.0096	*	(0.0054)	0.0095	*	(0.0053)
head_fem	-0.1470		(0.1012)	-0.1526		(0.1024)
femratio	-0.0513		(0.1305)	-0.0431		(0.1299)
depratio	0.2522	**	(0.0961)	0.2508	**	(0.0975)
popwt1	-0.0110	**	(0.0055)	-0.0113	**	(0.0054)
Village-level shocks						
drought	-0.0139		(0.0872)			
drought*North.Punjab				-0.0508		(0.1123)
drought*South.Punjab				0.3707	**	(0.1833)
drought*Sindh				-0.1024		(0.1657)
flood	-0.5508	**	(0.2467)			
flood*South.Punjab				-0.9674	**	(0.4054)
flood*Sindh				-0.5190	**	(0.2596)
Idiosyncratic shocks						
health_shock	-0.1190	*	(0.0670)			
health_shock*North.Punjab				-0.2556	**	(0.1101)
health_shock*South.Punjab				-0.1358		(0.0882)
health_shock*Sindh				-0.0328		(0.1115)
F-stat for zero slopes#	3.34	***		3.24	***	
F-stat for homogenous impact#				1.15		
R-squared	0.075			0.080		

Notes: NOB is 1,308. Estimated by weighted least squares with household size as weights. Cluster-robust standard errors are reported in parenthesis (village as the cluster), statistically significant at the 10% *, 5% ** and 1% level. The number of clusters is 94.

“F-stat for zero slopes” indicates the F statistics for the null hypothesis that the empirical model has no explanatory power. It is distributed as F(19,93) for specification (i) and F(24,93) for specification (ii). “F-stat for homogenous impact” indicates the F statistics for the null hypothesis of specification (i) against (ii) and distributed as F(5,93).

Table 6. Sensitivity of consumption changes and household characteristics

	Definition of village-level shocks#					
	Default			Alternative		
	Coef.		S.E.	Coef.		S.E.
Region fixed effects	(Yes)			(Yes)		
Household characteristics	(Yes)			(Yes)		
Village-level shocks and their interaction terms with household characteristics						
drought	0.0979		(0.3138)	0.0108		(0.2833)
drought*landacre	0.0010		(0.0076)	0.0034		(0.0068)
drought*nfe_perm	0.0079		(0.1075)	-0.0310		(0.1072)
drought*cc_fml	-0.1197		(0.1270)	-0.0970		(0.1148)
drought*head_age	-0.0069	*	(0.0041)	-0.0055		(0.0040)
drought*head_sch	-0.0100		(0.0192)	-0.0039		(0.0177)
drought*depratio	0.6721	**	(0.3213)	0.6460	**	(0.2852)
flood	1.1897	**	(0.5751)	0.5749		(0.3487)
flood*landacre	0.0241	***	(0.0083)	0.0152	***	(0.0052)
flood*nfe_perm	-0.0476		(0.3527)	-0.0481		(0.2563)
flood*cc_fml	-0.0232		(0.2036)	0.0497		(0.1123)
flood*head_age	-0.0324	***	(0.0098)	-0.0146	**	(0.0067)
flood*head_sch	-0.0377	*	(0.0208)	-0.0200		(0.0142)
flood*depratio	-0.6968		(0.6917)	-0.8220	**	(0.3623)
Idiosyncratic shocks and their interaction terms with household characteristics						
health_shock	0.0725		(0.2488)	0.0660		(0.2440)
health_shock*landacre	-0.0001		(0.0084)	0.0000		(0.0086)
health_shock*nfe_perm	-0.0470		(0.1278)	-0.0593		(0.1293)
health_shock*cc_fml	-0.2736	**	(0.1164)	-0.2584	**	(0.1185)
health_shock*head_age	0.0010		(0.0037)	0.0013		(0.0037)
health_shock*head_sch	0.0013		(0.0133)	0.0006		(0.0131)
health_shock*depratio	-0.1159		(0.2773)	-0.1458		(0.2744)
F-stat for zero slopes##	4.20	***		5.33	***	
F-stat for homogenous impact##	2.96	***		2.94	***	
R-squared	0.104			0.110		

Notes: See Table 5 for the estimation methodology, number of observations and list of explanatory variables not reported in this table.

"Default": Same as in previous tables (see Table 4 for its definition and statistics). "Alternative": Production shock variables corresponding to the larger of the last two years (Kharif 2002 and Rabi 2002/03, or, Kharif 2003 and Rabi 2003/04). The mean (standard deviation) is 0.332 (0.312) for drought, 0.119 (0.258) for flood.

"F-stat for zero slopes" indicates the F statistics for the null hypothesis that the empirical model has no explanatory power, distributed as F(37, 93). "F-stat for homogenous impact" indicates the F statistics for the null hypothesis of specification (i) in Table 5 and distributed as F(18,93).

Appendix Table. Sensitivity of the heterogeneity with respect to other specifications

	Definition of village-level shocks#								
	Default			Alternative (1)			Alternative (2)		
	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Basic specification (Default and Alternative (1) subtracted from Table 6)									
flood*landacre	0.0241	***	(0.0083)	0.0152	***	(0.0052)	0.0183	***	(0.0047)
flood*head_age	-0.0324	***	(0.0098)	-0.0146	**	(0.0067)	-0.0208	**	(0.0099)
health_shock*cc_fml	-0.2736	**	(0.1164)	-0.2584	**	(0.1185)	-0.2989	***	(0.1120)
Specification without health shocks									
flood*landacre	0.0244	***	(0.0083)	0.0154	***	(0.0052)	0.0186	***	(0.0048)
flood*head_age	-0.0321	***	(0.0097)	-0.0144	**	(0.0066)	-0.0207	**	(0.0098)
Each variable of X_{1i} has different slopes according to the region									
flood*landacre	0.0289	**	(0.0119)	0.0167	**	(0.0063)	0.0197	***	(0.0060)
flood*head_age	-0.0343	***	(0.0120)	-0.0140	*	(0.0080)	-0.0208	*	(0.0110)
health_shock*cc_fml	-0.2419	**	(0.1220)	-0.2123	*	(0.1225)	-0.2570	**	(0.1207)
The larger subsample for regression, not excluding outliers in the distribution of *dlnc* (NOB=1,373).									
flood*landacre	0.0217	***	(0.0083)	0.0141	***	(0.0053)	0.0175	***	(0.0047)
flood*head_age	-0.0340	***	(0.0095)	-0.0149	**	(0.0066)	-0.0238	**	(0.0109)
health_shock*cc_fml	-0.2328	*	(0.1257)	-0.2200	*	(0.1286)	-0.2555	**	(0.1236)
Dependent variable *dlnc* re-calculated under the assumption that the shadow prices of unpaid food consumption are 20% lower than the village prices.									
flood*landacre	0.0239	***	(0.0082)	0.0150	***	(0.0052)	0.0180	***	(0.0047)
flood*head_age	-0.0321	***	(0.0099)	-0.0142	**	(0.0068)	-0.0203	**	(0.0100)
health_shock*cc_fml	-0.2669	**	(0.1169)	-0.2512	**	(0.1190)	-0.2923	**	(0.1127)
Dependent variable replaced by the change in log food consumption per capita									
flood*landacre	0.0160	**	(0.0066)	0.0105	**	(0.0042)	0.0094	***	(0.0032)
flood*head_age	-0.0338	***	(0.0099)	-0.0151	**	(0.0063)	-0.0204	**	(0.0090)
health_shock*cc_fml	-0.2987	**	(0.1244)	-0.2967	**	(0.1247)	-0.3248	***	(0.1222)

Notes: All specifications include explanatory variables listed in Table 6. In this table, coefficients on three interaction terms are reported. The full estimation results are available on request.
Default = Default in Table 6. Alternative (1) = Alternative in Table 6. Alternative (2): Production shock variables corresponding to the last year (Kharif 2003 and Rabi 2003/04). The mean (standard deviation) of alternative (2): drought 0.306 (0.304), flood 0.060 (0.189).