Effectiveness of Rural Households' Coping Strategies against Aggregate Shocks in Developing Economies: Evidence from the 2008 Sichuan Earthquake

Ling Jin Mateusz Philipski Kevin Z. Chen

Abstract.

While rural households in developing countries deploy a series of risk coping strategies to insulate against shocks, their effectiveness relies extraordinarily on the nature of the shocks. Using unique datasets collected before and after the 2008 Sichuan earthquake, this paper examines the performance of all the principal coping strategies employed by the affected rural households. We find that the seven directly surveyed coping strategies can be ranked according to the receipts financed by applying them as depleting savings, government aid, subsidized bank loans, informal credit, private transfer, selling assets, and saving money by letting children drop out of school. In addition, the difference-in-differences (DID) estimation results show that the affected rural households also adjusted their behavior in response to the earthquake: they diversified their income through crop diversification and pursuing nonagricultural self-employment, and male household members increased their monthly days worked.

Key words: Aggregate Shock; Coping Strategy; Income Diversification; Labor Supply

JEL codes: Q12, Q54

1 Introduction

Although faced with considerable adverse shocks and dysfunctional formal financial and insurance markets, rural households in developing countries possess a wide range of *ex ante* risk management and *ex post* risk coping strategies to insulate their consumption against risks (e.g. Alderman and Paxson, 1994; Morduch, 1995). While the former refers to income skewing (e.g. Dercon and Christiaensen, 2011) and income diversification (e.g. Reardon, Delgado and Matlon, 1992), the latter includes precautionary saving (e.g. Rosenzweig and Wolpin, 1993), access to formal credit and insurance markets (e.g. Eswaran and Kotwal, 1989), labor supply (e.g. Giles, 2006), informal risk-sharing mechanisms (e.g. Townsend, 1994), as well as social safety nets (e.g. Coady, Grosh and Hoddinott, 2004).

The effectiveness of these risk management and coping strategies relies extraordinarily on the nature of the shocks against which rural households deployed (Morduch, 1999). Compared to idiosyncratic shocks, natural disasters and other aggregate shocks can invalidate local *ex post* risk-sharing mechanisms by trapping all the participating members in similar adverse situations, and their practically unanticipated nature disables the functioning of *ex ante* strategies designed to hedge against them in advance (World Bank, 2005). Therefore, without adequate external assistance, affected rural households have to depend exclusively on *ex post* self-insurance coping strategies, including precautionary saving, formal credit and insurance markets, informal credit, and labor supply.

Macroeconomic crises and natural disasters are two principal types of aggregate shocks. And natural disasters can be further categorized into sudden on-set events and long last ones.

This paper attempts to holistically examine the effectiveness of all the coping strategies employed by the affected rural households against the devastating 2008 Sichuan earthquake, a type of sudden on-set event, based on a unique longitudinal dataset collected before and after the earthquake. We find that the seven directly surveyed coping strategies can be ranked according the receipts financed by applying them as follows: depleting savings, government aid, subsidized bank loans, informal credit, private transfer, selling assets, and saving money by letting children drop out of school. The results of the DID estimation also show that rural households in hit area diversified their income by increasing crop diversity and pursuing

nonagricultural self-employment. Meanwhile, male household members increased their monthly days worked, but the effectiveness of the *ex post* labor supply was weakened by the macroeconomic setting in the aftermath of the earthquake.

The rest of the paper is organized as follows. Section 2 reviews all the major coping strategies against natural disasters reported in four types of disaster events. Section 3 describes the background of the 2008 Sichuan earthquake. Section 4 introduces the data sources, describes the losses at the village and household levels, the recovery trajectory in terms of assets, as well as the importance of seven directly surveyed coping strategies. Section 5 lays out our analytical framework and presents the main results of the DID estimation for the welfare impact of the earthquake, and the effectiveness of income diversification and *ex post* labor supply. The last section concludes.

2 Literature Review: Natural Disasters and Coping Strategies

Previous studies on natural disasters and coping strategies concentrate on four types of natural events: the Kobe earthquake in 1995, the hurricane Mitch striking Central American countries in 1998, the Bangladesh flood lasting for eight months in 1998, as well as several severe droughts in African countries. Private transfers and formal credit for households with collateral helped maintain consumption levels in the Kobe earthquake (Sawada and Shimizutani, 2008). Government relief significantly compensated for housing damage in Honduras after Hurricane Mitch (Morris and Wodon, 2003). The households living along forests in Honduras could diversify their production activities by accessing forests and selling forestry products after Hurricane Mitch (McSweeney, 2005). Borrowing from informal channels is identified as households' most important coping strategy during the Bangladesh flood, followed by selling assets (Ninno, Dorosh, and Smith, 2003). Agricultural workers coped with the Bangladesh flood by switching to the nonagricultural sector (Mueller and Quisumbing, 2011).

During the four major droughts in Zimbabwe in the period of 1983-1996, while the government's drought relief programs helped maintain household consumption levels, selling cattle or other grain stock, depleting savings and finding a job were sequentially the three most important self-insurance strategies against the most severe drought of 1992 in terms of financing food purchases (Kinsey, Burger and Gunning,

1998). Although some opposing evidence exists (Kazianga and Udry, 2006), liquidating livestock is frequently found to be used to buffer against adverse income shocks caused by droughts (Fafchamps, Udry and Czukas, 1998).

Labor supply is highlighted as an effective self-insurance coping strategy, since other strategies impose higher entrance barriers. Most evidence relates to labor supply as an *ex post* measure in response to adverse shocks at the household level. Male household members in India increase their hours of work to cope with idiosyncratic shocks to crop profits (Kochar, 1999). When a village's connections with the labor market improve, rural households in the village are less exposed to agricultural shocks in China (Giles, 2006). And rural households shift from employment in the agricultural sector to the nonagricultural sector and to jobs paid in in-kind wages to respond to rainfall variations (Ito and Kurosaki, 2009). Besides adult laborers, children are also pushed to work when exposed to negative shocks in Tanzania (Beegle, Dehejia and Gatti, 2006) and Guatemala (Guarcello, Mealli and Rosati, 2010).

Other than the *ex post* responses mentioned above, rural households in India are also more likely to participate in the labor market when facing riskier distributions of rainfall *ex ante* (Rose, 2001). And one study bridges the connections between *ex ante* production decisions and *ex post* labor supply by providing evidence that access to the labor market can encourage rural households to use more fertilizer (Lamb, 2003). Some studies even find supporting evidence at the aggregate level that rural-urban migration facilitates interprovincial consumption risk sharing (Du, He and Rui, 2011) and thus offers another channel to boost urbanization even when economic conditions are worse (Poelhekke, 2010).

However, the effectiveness of access to the labor market can be compromised under certain circumstances. Wages decreases were found in the aftermath of the Bangladesh flood (Mueller and Quisumbing, 2011) and after droughts in Brazil in the long run (Mueller and Osgood, 2009). And during Argentina's financial crisis, real wages declined dramatically, unemployment increased, and workers could not increase hours worked to counteract the decline in wages (McKenzie, 2004). Some theoretical research indicates that productive shocks can be linked to the labor market and translate into wage declines, especially for households with characteristics that make their labor supply inelastic, including: subsistence, incapacity of migration and being credit constrained (Jayachandran, 2006).

3 Background: the 2008 Sichuan Earthquake and China's Emergency Response

In May 12, 2008, a deadly earthquake of 8.0 M_s hit an extensive area covering nearly 500,000 square kilometers across ten provinces in China, with its hypocenter as shallow as 19 km beneath Wenchuan County, Sichuan province (Zhang *et al*., 2008). The rupture lasted for around 60 seconds and released 30 times the energy of the Great Hanshin (Kobe) earthquake of 1995 in Japan (Chen *et al*, 2008). Along with numerous aftershocks, the 2008 Sichuan earthquake eventually caused 69,227 deaths, 17,923 missing and 374,643 injured.[1] The total direct economic losses amounted to RMB 845 billion (US$ 132 billion).[2] This disaster is recorded as the 21st deadlies earthquake in the history of the world.[3] The damage in rural areas was especially extensive given the pervasiveness of faulty construction neglecting the government's seismic design codes (Ren, Weng and Lv, 2008), which resulted in the widespread collapse of buildings, and in turn was associated with severe casualties and assets destruction.

Following the immediate rescue operations, multi-dimensional measures were carried out to reinvigorate the hit areas. The Chinese government issued a three-year reconstruction plan worth RMB 1 trillion shortly after the earthquake,[4] equivalent to Sichuan province's annual GDP value in 2007 (NBS, 2012). The majority of the aid was invested in rebuilding housing (29%), infrastructure (21%), enterprises (14%), and public services (11%) (Huang and Bonschab, 2010, P38). The central government also worked out an innovative mode of pairwise reconstruction based on the principle of "one province to one hit county", in order to efficiently mobilize the government resources dedicated to rebuilding the affected areas (Bulte, Xu and Zhang, 2013). The commercial banks were also encouraged by the government to offer loans at subsidized interest rates and to relax mortgage requirements.[5]

---

[1] Please refer to the English webpage: http://earthquake-report.com/2011/05/10/the-may-12-2008-deadly-sichuan-earthquake-a-recap-3-years-later/.

[2] Please refer to the English webpage: http://news.xinhuanet.com/english/2008-09/04/content_9768590.htm.

[3] Please refer to the English webpage: http://en.wikipedia.org/wiki/List_of_natural_disasters_by_death_toll#Earthquakes.

[4] Please refer to the English webpage: http://www.theguardian.com/world/2008/aug/15/chinaearthquake.china.

[5] Chains' Ministry of Finance issued a document on subsidizing commercial banks to offer interest-free loans to the affected rural households within the duration of three years. Please refer to the Chinese webpage: http://www.mof.gov.cn/zhengwuxinxi/caizhengwengao/caizhengbuwengao2008/caizhengwengao2008dijiuqi/200812/t20081223_102157.html.

4 Data

4.1 Data Construction

The datasets used in this paper are constructed from two separate household surveys, the Sichuan Rural Household and Migration Survey (SRHMS), and the Sichuan component of the annual rural household survey administered by the Research Center of Rural Economy (RCRE), a subsidiary of China's Ministry of Agriculture. While SRHMS concentrates on one of the hardest-hit areas in Sichuan (referred to as county M thereafter), RCRE data covers more diverse geographic units including places further away from the quake center. Thus, the combination of these two datasets allows us to compare households in hit areas with those in non-hit areas.

SRHMS is a panel study of six villages in county M in the years 2007, 2009 and 2012. In each wave, around 800 households are surveyed.[6] RCRE is one of the most widely used resources for the study of Chinese rural households. The survey was set up in 1984, and reaches all initially-selected households each year until they move out of the village or have no more living members.[7] The Sichuan sample of RCRE also includes around 800 rural households from 16 villages across the province. Moreover, the two surveys collect data both from the household and village levels. Therefore, the datasets are composed of the two surveys at the household and village levels spanning 2007, 2009 and 2011, and allow us to examine adjustments in the short and intermediate term based on two rounds of post-quake data.

According to the 2008 Sichuan earthquake's seismic intensity,[8] all 6 villages of SRHMS and 1 village of RCRE lie in the category I quake-stricken areas, 5 RCRE sample villages are in category II quake-stricken areas, another 8 RCRE villages are in the category III quake-stricken areas, and 2 of RCRE are not in the quake-stricken areas. We merge the two datasets and divide all 22 sample villages into two groups: hit area villages, which include all category I quake-stricken and 4 category II villages from the RCRE sample;[9] and the non-hit area villages, which includes all the other

[6] More information about the SRHMS survey can be found in Feng et al. (2013).
[7] More information about the RCRE survey can be found in Benjamin, Brandt and Giles (2005) and Giles and Yoo (2007).
[8] Based on the seismic intensity of the quake, the Chinese government classified 10 counties as category I (most hard-hit) quake-stricken regions, 41 counties as category II (hard-hit), and as many as 186 counties as category III (hit) quake-stricken areas. Please refer to the Chinese webpage: http://www.chinanews.com/gn/news/2008/07-12/1310643.shtml.
[9] One of the RCRE category II sample villages was not affected by the earthquake despite being located in the state-designated disaster-stricken region, and is thus defined as non-hit rather than hit area in our analysis.

villages in the sample. After the combination, we select out a balanced panel of 1322 households, with 541 in non-hit areas and 781 in hit areas.[10] Table 1 reports pre-quake summary statistics on the following rural households' characteristics: welfare measures of assets, income and consumption, agricultural production, off-farm labor supply, nonagricultural self-employment, and demographic variables.

In addition, we administered the same supplemental survey to households in the RCRE sample at the end of 2011 and in the SRHMS sample in the summer of 2012, right after the completion of the three-year period of reconstruction. We collected comprehensive information related to the earthquake and reconstruction, both at the household and village levels, including losses in assets (housing, consumer durables, productive capital assets, and products stock in agricultural production), all the major coping strategies (aid from the government, donation from friends and relatives, bank loans, informal credit, selling assets, and letting children drop out of school, and work-for-aid programs), measures of reconstruction (house strengthening and rebuilding, institutional innovations, participation in the village's reconstruction decisions), and changes before and after the earthquake (mutual help, leisure behavior, gift exchange, etc.).

4.2 Losses and Assets Recovery

Losses in the earthquake are reported in Table 2 both at the village and household levels. Rural households' asset loss in the affected areas amounted to RMB 10,645 yuan on average. The damage to houses served as the largest component of the destruction, accounting for 83 percent of the total loss. Loss of consumer durables, productive capital assets and agricultural product stocks accounted for 3, 4 and 10 percent, respectively. Damage summarized at the village level also revealed huge housing losses, which also resulted in extensive casualties. There were 278 houses impaired and 706 collapsed on average in each sample hit village. Infrastructure- (roads and bridges) and public service- (schools and hospitals) related losses were

[10] We have tried an alternative way to categorize the sample villages into three groups: hard-hit villages (including 7 villages located in the category I quake-stricken areas), hit villages (including 5 villages located in the category II quake-stricken areas), and non-hit villages (including 8 villages in the category III quake-stricken areas and 2 villages not in the quake-stricken areas). The results show that the estimated coefficients of key variables for hit villages are not significantly different from the non-hit villages as a treatment group. Thus, we merge hit and non-hit villages into one treatment group.

modest, most likely because our affected villages are located on the plains and as public goods provision in rural areas was at a fairly low level.

Since the major losses in the earthquake involved the destruction of assets, the recovery trajectory of the affected rural households' asset holdings can most effectively reflect their resilience. As displayed in Figure 1, the value of the three types of assets bounced back at differentiated speeds during the three-year reconstruction period. The value of houses for the affected households increased immediately following the earthquake and surpassed the value of their counterpart's holdings hereafter. However, while the affected households' expenditures on consumer durables were increased the same as that of the non-affected households in 2009, they largely lagged behind in 2011. And the increase in the value of productive capital assets followed a similar pattern across areas.

4.3 Directly Surveyed Coping Strategies

The question that follows the rapid recovery of the affected rural households is: by which means did they manage to restore their asset holdings? Our surveys considered all the principal coping strategies documented in the existing literature, including government aid, formal and informal credit, private transfer, assets selling and saving money by letting children drop out of school. As reported in Table 3, each rural household obtained an average total amount of RMB 43,055 yuan through the use of all the six strategies. Government aid contributed to 55.2 percent of total receipts (RMB 23,774 yuan), which came mostly in the form of house reconstruction and reinforcement subsidies (RMB 19,756 yuan, 45.9 percent).[11] Bank loans served as the second largest financing source (RMB 12,812 yuan, 29.8 percent), as the government encouraged commercial banks to issue loans at subsidized interest rates for three years. The rest of the sources can be ranked as follows: informal credit (RMB 6,378 yuan, 14.8 percent), private transfers (RMB 282 yuan, 0.7 percent), selling assets (RMB 147 yuan, 0.3 percent) and letting children drop out of school (RMB 10 yuan, 0.0 percent).

Previous studies on coping strategies typically assume that informal risk-sharing mechanisms collapse in face of aggregate shocks, because all the participants in the network are trapped in the adverse situations. But a significant proportion of the

[11] Subsidies for strengthening and rebuilding houses were distributed mainly both based on household size: for households with 1-3 people, RMB 16,000 was provided; for households with 4-5 people, RMB 19,000; for households with 6 or more people, RMB 22,000. On average each household received RMB 20,000 (US$3,100).

affected rural households in our sample did exploit the informal risk-sharing mechanism in coping with the earthquake shock. According to our surveys, two important risk-sharing mechanisms, informal credit and private transfer, worked in the aftermath of the earthquake.

The characteristics on the network of informal credit are reported in Table 4. 208 out of 781 rural households in hit area borrowed 344 credits from informal channels, amounted to the average of RMB 23.0 thousand yuan per household. 97.7 percent of all the loans claimed no interest at all. The affected rural households borrowed 64.2 and 14.2 percent of loans in frequency from their immediate and collateral relatives, respectively. And they sustained the network of informal credit by having 2.5 meetings and making 2.6 phone calls with their lenders. 91.3 percent visited their lenders in holidays and festivals, and 96.5 percent attended their weddings and funerals. Out of our expectation, 77.9 percent of lenders were also affected by the earthquake, implying that the geographic coverage of the informal credit network was principally bounded in the hit area.

Table 5 displays the characteristics on the network of private transfer. Only 55 out of 781 affected households were granted 67 private transfers of RMB 3,008 yuan on average. The network of private transfer was also mainly built on immediate and collateral relatives. 65.7 and 26.9 percent of transfers in frequency came from them, respectively. The network of private transfer against the earthquake shock took up larger coverage than that of informal credit. 30.0, 31.3 and 16.4 percent of donators lived out of the township, county and province where recipients were located. Then not surprisingly less proportion of donators was affected by the earthquake than the proportion of lenders was. Based on the comparison between informal credit and private transfer, it can be concluded that the latter functioned more weakly than the former, but it dispersed the shock over larger geographical area than the former.

Since house restoration was the principal and costliest reconstruction task, our survey also documented the affected rural households' spending on and financing resources for house strengthening and rebuilding, respectively. As reported in Table 4 and 5, it cost an affected household RMB 7,109 yuan to strengthen their houses in 0.9 months but RMB 83,036 yuan to rebuild them in 4.7 months on average. The funding for strengthening and rebuilding houses mainly came from four sources: government subsidies, formal and informal credit, and savings. The proportions contributed by the four sources were uneven and distinctive for house repair and reconstruction.

Expenditure on house repair was mostly sponsored by government subsidies, which accounted for 45 percent of the total cost. But house reconstruction depended more on savings, which amounted to 38 percent of total expenditure.

5 Empirical Framework and Results

5.1 Empirical Framework

Besides the use of coping strategies that can be inquired directly in survey, the affected rural households could also adjust their production behavior to mitigate the earthquake shock. In order to examine the relative changes in the production activities of rural households in hit area compared to those of their counterpart in non-hit area. Specifically, we will examine their adjustments in income diversification and *ex post* labor supply. We use the classic DID specification as follows:

$$y_{it} = \alpha + \beta H_i + \gamma_1 year09_t + \gamma_2 year11_t + \delta_1 H_i \cdot year09_t + \delta_2 H_i \cdot year11_t + X_{it}'\theta + \varepsilon_{it} \quad (1)$$

where y_{it} is household i' outcome in year t. H_i is the dummy variable indicating whether the household is located in a non-hit area (H_i =0) or a hit area (H_i =1). $year09_t$ and $year11_t$ is the dummy variable that signifies whether the survey year is 2009 or 2011, respectively. X_{it} is a vector of the household's characteristics, including age of the household head and its square, household size and its square, gender of the head, number of working-age laborers (between 16 and 60 years old), education level of the head, acreage of arable land, and whether a household member is a party member. ε_{it} is an error term, clustered at the village level to adjust for within-village correlations.

5.2 Welfare Impact of the Earthquake: Assets, Income and Consumption

The impact of natural disasters can be gauged both in the short and long terms. The studies that adopt a long-run perspective find the evidence of adverse effects on economic growth (Loayza et al., 2012), fertility (Finlay, 2009), children's nutrition (Baez and Santos, 2007), human capital accumulation (Xu, 2013). In the short run, the existing literature concentrates on measuring the impact of natural disasters on assets (Morgues, 2011), income (Carter et al., 2007), consumption (Sawada and Shimizutani, 2008), livelihood (den Berg, 2010), and poverty rates (Skoufias, 2003).

Due to the limited span of our datasets, we could only examine the short-run and immediate impact of the 2008 Sichuan earthquake on rural households' welfare, and in doing so we adopt the prevalent indices of assets, income and consumption. As reported in Table 5, the estimation results on value of the three assets in Column 1 further verify their evolving recovery path before and after the earthquake displayed in Figure 1. Rural households in hit area invested significantly more in housing, slowed down spending on consumer durables, and steadily invested in productive capital assets relative to their counterparts in non-hit area. In addition, while income and consumption levels were continually accruing in two areas after 2007, the adverse impact on the affected rural households' welfare was only evident in per capita income as of 2011, but out of expectation their consumption augmented significantly in 2009 on the contrary (Column 2 and 3).

5.3 Income Diversification

Income diversification can be observed at three levels. Firstly, farmers can diversify the crops they plant in scattered plots to adapt to differentiated micro climates and soils and to promote flood and drought resistance, or to manage a portfolio of the crops whose prices and yields are not highly correlated. The second level is that farmers can allocate labor and capital among cultivation, forestry husbandry, and fishery within on-farm production. Furthermore, they can also diversify their production activities among the whole income portfolio composed of agricultural production, off-farm labor supply and nonagricultural self-employment.

We examine whether the affected rural households adopted the strategy of income diversification at all three levels. We adopt the entropy index to measure the diversity of crops within cultivation, and whether the income source of husbandry or fishery was owned, and the types of poultry and livestock raised to measure the diversity of agricultural activities. Within the income portfolio, we test rural households' access to nonagricultural self-employment as the existing literature often regards it as the business with high entry barriers in developing countries (e.g., Reardon, Delgado and Matlon, 1992).

The entropy index and the Herfindalh index are widely used in the measurement of diversification. The former is more advantageous than the latter as it is less

sensitive to maximum and minimum values (Jaquemin and Berry, 1979). The formula of the entropy index is as follows:

$$entropy_{it} = \sum_{j=1}^{n} p_{j,it} \ln(1/p_{j,it}) \quad (2)$$

where $entropy_{it}$ is the household i's entropy index value in year t. $p_{j,it}$ is the planting area of crop j. The entropy is monotonically increasing with crop diversity.

Table 6 presents the estimation results for income diversification within cultivation and on-farm production. Rural households in Sichuan reduced their crop diversity and the number of the types of poultry and livestock, and were also less likely to engage in husbandry or fishery after the earthquake. This implies that against the background of rising wages, rural households gradually exited from labor-intensive agricultural production. Compared to the general tendency, however, crop diversity in hit area increased significantly in 2009 (Column 1), indicating that the affected rural households diversified cultivation to mitigate the earthquake shock. But they didn't diversify into husbandry or fishery, probably because the husbandry and fishery industries suffered severe damage and the resuming of their operation required large amounts of money and were also associated with greater exposure to high profit risk than cultivation.

The estimated results for income diversification within the overall income portfolio are reported in Table 7. As for the general trends, rural households in Sichuan were quitting from nonagricultural self-employment, which was consistent with the findings of Wang et al. (2008), but those staying in the sector earned more money from this source. On the contrary, the affected households exhibited higher probability of access to the sector in both 2009 and 2011. However, those households who remained in the sector did not derive more income from it, and no significant changes were observed in the number of own or employed laborers. The results imply that the booming of nonagricultural self-employment in hit area created more lucrative opportunities without imposing substantial entrance barriers, which is often emphasized in the literature on livelihood diversification (e.g., Reardon, Delgado and Matlon, 1992); but the development of the sector only exhibited extensive margin instead of intensive margin.

5.4 Ex post Labor Supply

Following McKenzie (2004), we investigate the employment of *ex post* labor supply from the aspects of job entry and exit, and monthly days worked. As reported in Table 8, generally speaking, the probability of rural households in Sichuan entering the labor market did not change after the earthquake, but the number of male wage laborers increased, while female wage laborers' monthly days worked decreased. In comparison, neither the probability of participating in the labor market nor the number of male employees changed significantly, but the number of female wage earners decreased for the households in hit area. The results imply that the affected rural households did not increase their access to the labor market as a coping strategy to insulate against the earthquake shock.

As showed in Column 4 and 5, both male and female wage earners in Sichuan tended to reduce their monthly days worked, although only the latter exhibited a significant change. This is probably due to the economic depression caused by the 2008 financial crisis. For the households in hit area, however, while all the four estimated coefficients of the interactive terms showed positive signs, monthly days worked of male wage laborers increased significantly in 2009. The results imply that rural households in hit area resorted to the use of ex post labor supplies by increasing male members' work time. The application of this strategy could be also reinforced by the rise in local wages during the reconstruction period.

6 Conclusions

Rural households in developing countries can utilize a wide range of risk coping strategies to fill the gaps left by formal financial and insurance markets and to mitigate the negative impact of shocks. But the accessibility of those strategies is highly contingent upon the nature of the shocks. Natural disasters are a major source of aggregate shocks that exposes each household in the affected area to devastating loss. Due to their aggregate feature, the basic implication for the utilization of risk coping strategies against them is that informal risk-sharing mechanisms would come into collapse because all the participants are suffering from the loss; without external interventions, the affected households have to rely on self-insurance strategies exclusively and struggle more to bounce back.

This paper examines the effectiveness of the three types of risk coping strategies against the aggregate shock caused by the 2008 Sichuan earthquake, a typical representative type of sudden on-set natural disaster along with hurricane and volcanic eruption. Using unique longitudinal datasets collected before and after the devastating 2008 Sichuan earthquake, we find that the importance of seven coping strategies that were directly surveyed can be ranked as follows: depleting savings, government aid, subsidized bank loans, informal credit, private transfer, selling assets, and saving money by letting children drop out of school. Rural households in hit area also undertook the strategy of income diversification through increasing crop diversity and pursuing nonagricultural self-employment. Meanwhile, male household members increased their monthly days worked, but the effectiveness of the *ex post* labor supply was weakened by the macroeconomic setting in the aftermath of the earthquake.

References

Alderman, H., Paxson, C., 1992. Do the Poor Insure? A Synthesis of the Literature on Risk and Consumption in Developing Countries. *World Bank Policy Research Working Paper Series WPS 1008*. Washington, DC: World Bank.

Baez, J. E., Santos, I. V., 2007. Children's Vulnerability to Weather Shocks: A Natural Disaster as a Natural Experiment. *Working paper*.

Beegle, K., Dehejia, R. H., Gatti, R., 2006. Child Labor and Agricultural Shocks. *Journal of Development Economics*. 81, 80-96.

Bulte, E., Xu, L., Zhang, X., 2013. Does Aid Promote or Hinder Industrial Development? "Quake" Lessons from China", *working paper*.

Coady, D. P., Grosh, M. E., Hoddinott, J., 2004. *Targeting of transfers in developing countries: Review of Lessons and Experience*. World Bank Publications.

Del Ninno, C., Dorosh, P. A., Smith, L. C., 2003. Public Policy, Markets and Household Coping Strategies in Bangladesh: Avoiding a Food Security Crisis Following the 1998 Floods. *World Development*. 31(7), 1221-1238.

den Berg, M., 2010. Household Income Strategies and Natural Disasters: Dynamic Livelihoods in Rural Nicaragua. *Ecological Economics*. 69, 592-602.

Dercon, S., Christiaensen, L., 2011. Consumption Risk, Technology Adoption and Poverty Traps: Evidence from Ethiopia. *Journal of Development Economics*. 96(2), 159-173.

Du, J., He, Q., Rui, O. M., 2011. Channels of Interprovincial Risk Sharing in China. *Journal of Comparative Economics.* 39(3), 383-405.

Eswaran, M., Kotwal, A., 1989. Credit as insurance in agrarian economies. *Journal of Development Economics*. 31(1), 37-53.

Fafchamps, M., Udry, C., Czukas, K., 1998. Drought and Saving in West Africa: Are Livestock a Buffer Stock? *Journal of Development Economics*. 55(2), 273-305.

Feng, S., Lu, J., Nolen, P., Wang, L., 2013. The Effect of Natural Disaster and Government Aid on the Income and Consumption of Rural Households: Evidence from the Wenchuan Earthquake. in Chen, K., Zhang, Q., Wang, Z., Hsu, C., Zhang, X. eds., Chapter 3, *"Quake" Lessons from China: Consequences, Coping and Rebuilding Strategies*, submitting to International Food Policy Research Institute' Publication Review Committee for a Consideration of Publication.

Finlay, J. E., 2009. Fertility Response to Natural Disasters: the Case of Three High Mortality Earthquakes. *Working paper*.

Giles, J., 2006. Is Life More Risky in the Open? Household Risk-Coping and the Opening of China's Labor Markets. *Journal of Development Economics.* 81, 25-60.

Giles, J., Yoo, K., 2007. Precautionary Behavior, Migrant Networks, and Household Consumption Decisions: An Empirical Analysis Using Household Panel Data from Rural China. *Review of Economics and Statistics*. 89(3), 534-551.

Guarcello, L., Mealli, F., Rosati, F. C., 2010. Household Vulnerability and Child Labor: the Effect of Shocks, Credit Rationing, and Insurance. *Journal of Population Economics*. 23, 169-198.

Hoddinott, J., 2006. Shocks and their Consequences across and within Households in Rural Zimbabwe. *Journal of Development Studies*. 42(2), 301-321.

Hornbeck, R., 2012. The Enduring Impact of the American Dust Bowl: Short- and Long-Run Adjustments to Environmental Catastrophe. *American Economic Review*. 102(4), 1477-1507.

Huang, C., Bonschab, T., 2010. *Social Impact Assessment on the Implementation of "The Master Plan on Reconstruction of the Wenchuan Earthquake"*. Social Sciences Academic Press, Beijing, China (In Chinese).

Ito, T. Kurosaki, T., 2009. Weather Risk, Wages in Kind, and the Off-Farm Labor Supply of Agricultural Households in a Developing Country. *American Journal of Agricultural Economics*. 91(3): 697-710.

Jayachandran, S., 2006. Selling Labor Low: Wage Responses to Productivity Shocks in Developing Countries. *Journal of Political Economy*. 114(3), 538-575.

Kahn, M. E., 2005. The Death Toll from Natural Disasters: The Role of Income, Geography, and Institutions. *Review of Economics and Statistics.* 87(2), 271-284.

Kazianga, H., Udry, C., 2006. Consumption Smoothing? Livestock, Insurance and Drought in Rural Burkina Faso. *Journal of Development Economics*. 79(2), 413-446.

Kinsey, B., Burger, K., Gunning, J. W., 1998. Coping with Drought in Zimbabwe: Survey Evidence on Responses of Rural Households to Risk. *World Development*. 26(1), 89-110.

Kochar, A., 1999. Smoothing Consumption by Smoothing Income: Hours-of-Work Responses to Idiosyncratic Agricultural Shocks in Rural India. *Review of Economics and Statistics*. 81(1), 50-61.

Lamb, R. L., 2003. Fertilizer Use, Risk, and Off-Farm Labor Markets in the Semi-Arid Tropics of India. *American Journal of Agricultural Economics*. 85(2), 359-371.

Linnerooth-Bayer, J., Mechler, R., Pflug, G., 2005. Refocusing Disaster Aid. *Science*. 309(12), 1044-1046.

Loayza, N. V., Olaberria, E., 2012. Natural Disasters and Growth: Going Beyond the Averages. *World Development*. 40(7), 1317-1336.

Macrae, J., 2002. The New Humanitarianism: A Review of Trends in Global Humanitarian Action. *HPG Report*, 11.

McKenzie, D. J., 2004. Aggregate Shocks and Urban Labor Market Responses: Evidence from Argentina's Financial Crisis. *Economic Development and Cultural Change*. 52(4), 719-758.

McSweeney, K., 2005. Natural Insurance, Forest Access, and Compounded Misfortune: Forest Resources in Smallholder Coping Strategies before and after Hurricane Mitch, Northeastern Honduras. *World Development*. 33(9), 1453-1471.

Mogues, T., 2011. Shocks and Asset Dynamics in Ethiopia. *Economic Development and Cultural Change*. 60(1), 91-120.

Morduch, J., 1995. Income smoothing and consumption smoothing. *Journal of economic Perspectives*. 9(3), 103-114.

Morduch, J., 1999. Between the State and the Market: Can Informal Insurance Patch the Safety Net? *World Bank Research Observer*. 14(2), 187-207.

Morris, S. S., Wodon, Q., 2003. The Allocation of Natural Disaster Relief Funds: Hurricane Mitch in Honduras. *World Development*. 31(7), 1279-1289.

Mueller, V. A., Osgood, D. E., 2009. Long-term Impacts of Droughts on Labour Markets in Developing Countries: Evidence from Brazil. *Journal of Development Studies*. 45(10), 1651-1662.

Mueller, V., Quisumbing, A., 2011. How Resilient are Labour Markets to Natural Disasters? The Case of the 1998 Bangladesh Flood. *Journal of Development Studies*. 47(12), 1954-1971.

National Bureau of Statistics, 2012. *China Statistical Yearbook 2012*. China Statistics Press, Beijing, China.

Poelhekke, S., 2010. Urban Growth and Uninsured Rural Risk: Booming Towns in Bust Times. *Journal of Development Economics*. 96(2), 461-475.

Reardon, T., Delgado, C., Matlon, P., 1992. Determinants and Effects of Income Diversification amongst Farm Households in Burkina Faso. *Journal of Development Studies*. 28(2), 264-296.

Ren, X., Weng, D., Lv, X., 2008. Earthquake Damage of Masonry Buildings in Sichuan Province and Discussion on Seismic Design for Primary and Middle School Buildings. *Earthquake Resistant Engineering and Retrofitting*. 30(4), 71-76 (in Chinese).

Rosenzweig, M. R., Wolpin, K. I., 1993. Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-income Countries: Investments in Bullocks in India. *Journal of Political Economy*. 101(2), 223-244.

Sawada, Y., Shimizutani, S., 2008. How Do People Cope with Natural Disasters? Evidence from the Great Hanshin-Awaji (Kobe) Earthquake in 1995. *Journal of Money, Credit and Banking*. 40(23), 463-488.

Skoufias, E., 2003. Economic Crises and Natural Disasters: Coping Strategies and Policy Implications. *World Development*. 31(7), 1087-1102.

Stromberg, D., 2007. Natural Disasters, Economic Development, and Humanitarian Aid. *Journal of Economic Perspectives*. 21(3), 199-222.

Townsend, R. M., 1994. Risk and insurance in village India. *Econometrica*. 62(3), 539-591.

Toya, H., Skidmore, M., 2007. Economic Development and the Impacts of Natural Disasters. *Economic Letters*. 94, 20-25.

World Bank, 2005. *Managing Agricultural Production Risk: Innovations in Developing Countries.* World Bank Agricultural and Rural Development Department Report No. 32727.

Xu, G., 2011. Long-Run Consequences of Natural Disasters: Evidence from Tangshan. *Working paper*.

Zhang, P., Xu, X., Wen, X. Z., Ran, Y., 2008. Slip Rates and Recurrence Intervals of the Longmen Shan Active Fault Zone, and Tectonic Implications for the Mechanism of the May 12 Wenchuan Earthquake, 2008, Sichuan, China. *Chinese Journal of Geophysics*. 51(4), 1066-1073 (in Chinese).

Zimmerman, F. J., Carter, M. R., 2003. Asset Smoothing, Consumption Smoothing and the Reproduction of Inequality under Risk and Subsistence Constraints. *Journal of Development Economics*. 71(2), 233-260.

Table 1—Household Characteristics in 2007, By Hit Level

	Non-hit area			Hit area		
	Mean	Median	SD	Mean	Median	SD
Panel A. Assets, Consumption and Income						
Value of assets (RMB)						
Housing	28,930	13,403	39,092	15,187	5,814	24,300
Consumer durables	803	116	1,595	1,277	581	2,003
Productive capital assets	1,951	0	11,247	2,138	72	8,866
Household monthly consumption (RMB)	859	784	434	1,027	763	1,124
Per capita monthly consumption (RMB)	221	197	123	318	237	378
Household annual net income (RMB)	23,025	20,093	14,984	19,408	15,174	20,176
Per capita annual net income (RMB)	5,004	4,146	3,945	5,225	4,322	5,148
Agricultural production	1,867	1,422	2,876	1,691	1,000	3,779
Cultivation and forestry	1,179	971	1,184	863	693	903
Husbandry and fishery	681	313	2,545	825	193	3,575
Nonagricultural self-employment	587	0	2,710	189	0	936
Off-farm labor supply	2,601	2,151	2,909	3,005	2,326	3,378
Other income	764	243	1,756	615	21	1,790
Panel B. Agricultural Production						
Diversity of crops (the Entropy index)	1.167	1.332	0.629	0.993	1.006	0.404
Panel C. Off-farm Labor Supply						
Number of laborers	0.8	0.0	1.0	0.9	0.0	0.9
Proportion of male wage laborers (%)	58.6	50.0	31.3	59.9	50.0	33.3
Monthly days worked (days/month)	24.3	25.0	5.9	23.1	25.4	7.8
Panel D. Nonagricultural Self-Employment						
Percentage of households operating nonagricultural self-employment (%)	27.4			10.9		
Number of laborers	0.2	0.0	0.6	0.1	0.0	0.4
Proportion of male laborers (%)	50.9	50.0	37.6	54.3	50.0	36.7
Panel E. Demographic Variables						
Age of the head	51.1	51.0	11.8	51.6	52.0	11.6
Household size	4.3	4.0	1.7	3.4	3.0	1.2
Number of working-age laborers	3.0	3.0	1.4	2.5	3.0	1.2
Acreage of arable land (mu)	4.2	3.0	4.1	3.3	3.0	1.7
Education of the head (years of being at school)						
<= 6	56.0			60.6		
> 6, <= 9	36.8			32.7		
> 9	4.6			5.9		
Female household head (%)	5.9			6.8		
Proportion of households with a member being party member (%)	12.0			8.6		
Observations		541			781	

Notes:
(1) All the prices have been deflated at the level of 2011.

Table 2—Loss in the 2008 Sichuan Earthquake at the Household and Village Level

	Mean	Median	SD
Panel A. Loss at the household level			
Housing	8,832	5,044	12,492
Consumer durables	317	0	1,373
Productive capital assets	373	0	2,984
Products of cultivation and forestry	396	174	604
Products of husbandry and fishery	702	0	4,345
Total	10,645	6,196	14,439
Panel B. Loss at the village level			
Number of persons injured	51	3	108
Number of persons died	10	2	17
Number of Houses impaired	278	85	394
Number of Houses collapsed	706	804	631
Loss of the collective's assets (yuan)	64	77	42
Length of roads damaged (kilometer)	2.8	0.0	9.0
Number of bridges damaged	1.7	0.0	3.6
Number of schools damaged	0.2	0.0	0.4
Number of hospital damaged	0.5	1.0	0.5

Notes:
(1) All the prices have been deflated at the level of 2011;
(2) Loss at the village and household level are calculated based on 11 hit area villages and 781 rural households residing in those villages.

Table 3—An Overview of Directly Surveyed Coping Strategies

	Mean	Median	SD
Aid from government	23,774	25,654	27,920
Relief	4,018	3,542	7,515
Cash	3,419	3,025	6,935
In-kinds	599	303	2,286
Housing subsidies	19,756	20,925	26,156
Loans	19,190	21,810	23,745
From banks	12,812	10,905	14,561
From relatives and friends	6,378	0	16,709
Private transfer	282	0	2,082
Selling assets	147	0	1,533
Money saved by letting children drop out of school	10	0	276
Total	43,055	43,360	41,198
Observations		781	

Notes:
(1) All the prices have been deflated at the level of 2011.

Table 4—Characteristics on the Network of Informal Credit in Hit Area

	Mean (SD)/Frequency
Observations of sample households	208
Occurrence of loans	344
Amount borrowed (10,000 yuan)	2.3 (1.8)
Proportion of loans claiming interest (%)	2.3
Relationship with lenders (%)	
Immediate relatives	64.2
Collateral relatives	14.2
neighborhood	2.9
Co-workers	2.9
Business partners	0.3
Others	1.5
Whether lender is affected by the earthquake (%)	77.9
Comparison with lenders' income level (%)	
Lenders are wealthier	75.6
Lenders are poorer	2.0
Similar	5.8
Frequency of meetings with lenders (per month)	2.5 (3.1)
Frequency of calling up lenders (per month)	2.6 (2.7)
Whether socializing with lenders in holidays and festivals (%)	91.3
Whether attending lenders' wedding and funerals (%)	96.5

Notes:
(1) All the prices have been deflated at the level of 2011.

Table 5—Characteristics on the Network of Private Transfer in Hit Area

	Mean (SD)/Frequency
Observations of sample households	55
Occurrence of private transfers	67
Amount transferred	3,008 (5,699)
Cash	2,705 (5,767)
In-kinds	303 (584)
Relationship with donators (%)	
Immediate relatives	65.7
Collateral relatives	26.9
neighborhood	3.0
Co-workers	1.5
Business partners	1.5
Location of donators' residence (%)	
Within village	13.4
Within township/out of village	6.0
Within county/out of township	30.0
Within province/out of county	31.3
Out of province	16.4
Whether donators were affected by the earthquake (%)	49.3

Notes:
(1) All the prices have been deflated at the level of 2011.

Table 6—Housing Strengthening and Rebuilding

	Mean	Median	SD
Panel A. House Reinforcement			
Number of households		117	
Time spent (month)	0.9	0.5	1.1
Housing area (square meters)	144	125	64
Expenditure (RMB yuan)	7,109	3,337	12,727
Sources of monetary input (RMB yuan)			
Subsidies from government	3,224	2,225	4,680
Loan from banks	464	0	3,587
Informal credit	372	0	3,086
Savings	3,049	0	9,233
Panel B. House Reconstruction			
Number of households		557	
Time spent (month)	4.7	4.0	3.2
Housing area (square meters)	186	180	95
Expenditure (RMB yuan)	83,036	72,581	55,226
Sources of monetary input (RMB yuan)			
Subsidies from government	26,725	25,585	27,538
Loan from banks	16,218	21,692	14,215
Informal credit	8,807	0	18,780
Savings	31,287	21,507	39,704
Observations		781	

Notes:
(1) All the prices have been deflated at the level of 2011.

Table 7—Estimated Impact of the Earthquake on Assets, Income and Consumption

	Assets			Income		Consumption	
	(1)	(2)	(3)	(1)	(2)	(1)	(2)
	Log value of housing	Log value of consumer durables	Log value of productive capital assets	Log total net income	Log per capita income	Log total monthly consumption	Log per capita consumption
Hit area	0.064	1.906***	1.772**	-0.372**	-0.277*	0.086	0.079
	(0.240)	(0.570)	(0.701)	(0.168)	(0.155)	(0.101)	(0.097)
Year 2009	0.375***	1.879***	0.216	0.077	0.141**	0.088	0.087
	(0.121)	(0.492)	(0.165)	(0.066)	(0.062)	(0.055)	(0.052)
Year 2011	0.634***	3.301***	1.462	0.438***	0.585***	0.331***	0.332***
	(0.132)	(0.789)	(0.897)	(0.052)	(0.050)	(0.067)	(0.064)
Hit area ×year 2009	1.108***	-1.573***	0.431	0.052	0.009	0.273***	0.275***
	(0.295)	(0.520)	(0.252)	(0.091)	(0.091)	(0.089)	(0.088)
Hit area ×year 2011	0.995***	-2.680***	-0.559	-0.300	-0.379**	0.065	0.091
	(0.298)	(0.840)	(0.926)	(0.176)	(0.152)	(0.149)	(0.131)
R^2	0.135	0.157	0.105	0.268	0.113	0.171	0.142
Observations	3,966	3,966	3,966	3,966	3,966	3,966	3,966

Notes:
(1) Village-clustered robust standard errors are reported in parentheses;
(2) To save space, we did not report the estimation results for the variables of household characteristics;
(3) ***, **, and * indicates significance at the 1, 5, and 10 percent level, respectively.

Table 8—Estimated Adjustments in Income Diversification: within Cultivation and On-farm Production

	(1)	(2)	(3)
	OLS	Probit	Poisson
	Diversity of crops (the Entropy index)	Whether own income of husbandry and fishery	Number of types of poultry and livestock
Hit area	-0.146	0.063	0.142
	(0.131)	(0.082)	(0.152)
Year 2009	-0.088***	-0.047	-0.092
	(0.022)	(0.036)	(0.059)
Year 2011	-0.251**	-0.135***	-0.220***
	(0.104)	(0.038)	(0.084)
Hit area ×year 2009	0.094***	-0.135**	-0.277***
	(0.033)	(0.055)	(0.074)
Hit area ×year 2011	0.108	-0.101**	-0.313***
	(0.109)	(0.044)	(0.091)
$Chi^2/R^2/F$	0.075	212.1	1453
Observations	3,966	3,966	3,966

Notes:
(1) Village-clustered robust standard errors are reported in parentheses;
(2) Due to limited space, we did not report the estimation results for the variables of household characteristics;
(3) ***, **, and * indicates significance at the 1, 5, and 10 percent level, respectively.

Table 9—Estimated Adjustments in Income Diversification: within Income Portfolio

	(1) Probit	(2) OLS	(3) OLS	(4) Probit
	Whether own this source of income	Income of the households staying in this sector	Number of self-employed laborers	Whether hire laborers
Hit area	-0.133**	0.430	-0.303*	-0.001
	(0.064)	(0.291)	(0.181)	(0.007)
Year 2009	-0.083***	0.276	0.114	0.001
	(0.020)	(0.240)	(0.188)	(0.003)
Year 2011	-0.042	0.805***	0.220	-0.002
	(0.033)	(0.234)	(0.210)	(0.007)
Hit area ×year 2009	0.206***	0.244	0.155	0.007
	(0.061)	(0.305)	(0.249)	(0.007)
Hit area ×year 2011	0.139**	-0.225	0.047	0.003
	(0.069)	(0.340)	(0.264)	(0.009)
$Chi^2/R^2/F$	459.9	0.154	36.47	311.7
Observations	3,966	653	3,948	3,966

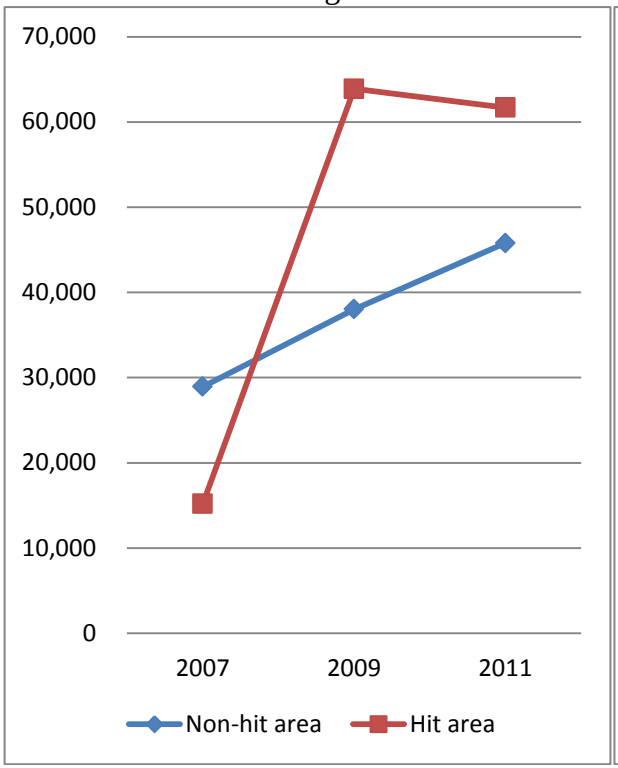
Notes:
(1) Village-clustered robust standard errors are reported in parentheses;
(2) Due to limited space, we did not report the estimation results for the variables of household characteristics;
(3) ***, **, and * indicates significance at the 1, 5, and 10 percent level, respectively.

Table 10—Estimated Adjustments in *Ex post* Labor Supply

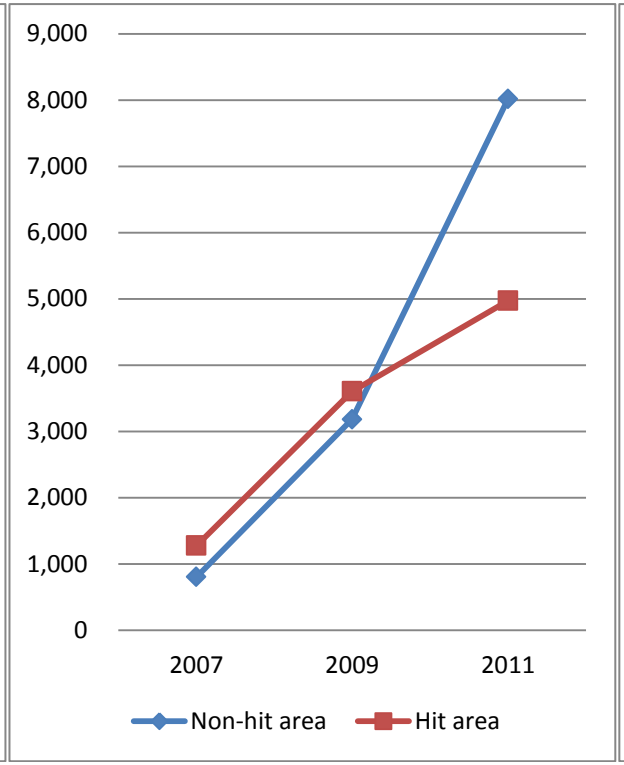
	(1)	(2)	(3)	(4)	(5)
	Household level	Household level	Household level	Individual level	Individual level
	Probit	Poisson	Poisson	Tobit	Tobit
	Whether own wage	Number of male wage laborers	Number of female wage laborers	Monthly days worked of male wage laborers	Monthly days worked of female wage laborers
Hit area	-0.105*	0.393**	0.170	-0.732	-0.761
	(0.054)	(0.165)	(0.207)	(1.143)	(1.372)
Year 2009	-0.011	0.109	0.116	-0.660	-1.022
	(0.042)	(0.071)	(0.089)	(0.688)	(0.861)
Year 2011	-0.012	0.155*	0.127	-1.010	-1.856*
	(0.052)	(0.088)	(0.090)	(0.799)	(1.101)
Hit area ×year 2009	0.018	-0.113	-0.151	1.459*	0.952
	(0.045)	(0.085)	(0.117)	(0.821)	(1.258)
Hit area ×year 2011	-0.055	-0.075	-0.216*	0.622	1.778
	(0.063)	(0.092)	(0.128)	(1.048)	(1.462)
$Chi^2/R^2/F$	1062	291.9	729.6	14.40	16.71
Observations	3,966	3,966	3,966	2,101	1,198

Notes:
(1) Column (1), (2), and (3) are estimated at the household level, and Column (4) and (5) at the individual level;
(2) Village-clustered robust standard errors are reported in parentheses;
(3) Due to limited space, we did not report the estimation results for the variables of household characteristics;
(4) ***, **, and * indicates significance at the 1, 5, and 10 percent level, respectively.

Panel A. Value of housing



Panel B. Value of consumer durables



Panel C. Value of productive capital assets

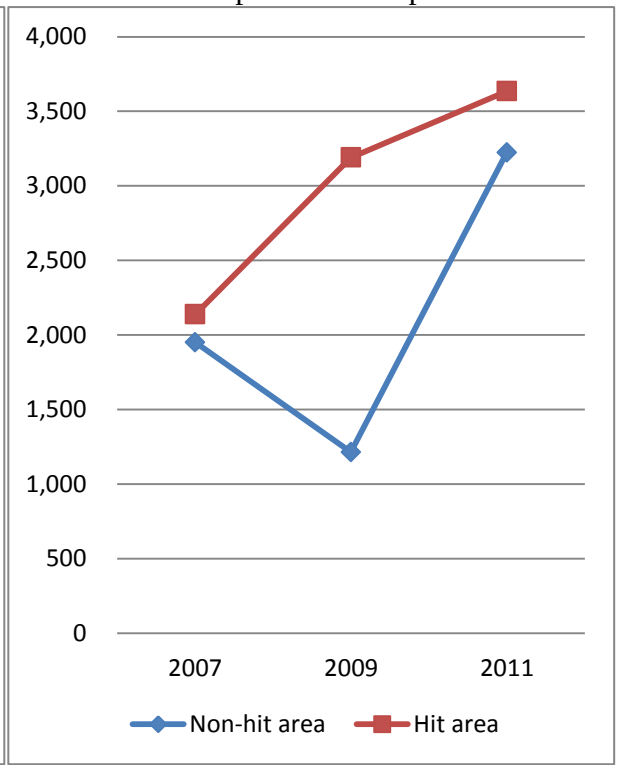


Figure 1—Trajectory of Rural Households' Asset Holdings during 2007-2011, by Hit Level

Notes:
(1) All the values have been deflated at the level of 2011.