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Optimal Risk Sharing Under Limited Commitment: Evidence From Rural Vietnam

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Abstract

We use panel data from a household survey conducted in Vietnam to analyze the effectiveness of informal risk sharing arrangements in protecting household consumption from idiosyncratic income shocks. We focus on the effects of reported harvest shocks and of estimated shocks to agricultural revenues on adult equivalent consumption. The full-insurance allocation is tested against a specified alternative under which contracts are not fully enforceable ex-post. We find that farmers hit by unfavorable events stabilize their consumption level below the village aggregate level, irrespective of the level of realized shocks. At the same time, farmers experiencing more favorable shocks enjoy higher consumption in proportion to the realized value of idiosyncratic shocks. Together, these finding are consistent with a simple 2-period model of optimal risk sharing with one-sided limited commitment. These results hold for total consumption and for non-durable consumption. We also find however some evidence supporting the full insurance hypothesis for food consumption.

JEL Classification: D8, I3, O1

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1 Introduction

Risk in poor agrarian economies is pervasive and has major influence on welfare. In these economies, agriculture is the main income generating activity which is very sensitive to the realization of natural shocks. Besides, formal institutions and insurance mechanisms designed to cope with such risks are often weak or nonexistent. Absent formal insurance markets however, other forms of more informal insurance mechanisms exist which allow households to mitigate the influence of risks on welfare. Fafchamps (2003) provides a comprehensive review of the various risk coping mechanisms in which households can engage.

A large literature have followed the work initiated by Cochrane (1991) and Mace (1991) for the US and by Townsend (1994) in rural India to test the major implication of the perfect risk sharing model that idiosyncratic shocks to income should leave consumption unaffected. Most of these studies were based on testing the null hypothesis of full insurance against an unspecified alternative model. The consensus that emerges from these studies is that even though in some cases observed consumption comes close to the full insurance allocation, perfect risk sharing is always rejected by the data. This has led researchers to work on models that provide a better account of the data. Two main hypothesis were proposed to help explaining the departure of the perfect insurance model from the data, namely information asymmetries and incentive problems.

In this paper, we use household survey data from Vietnam to study the effectiveness of risk sharing arrangements in insuring consumption among farmers. We focus on reported harvest shocks at household level and on idiosyncratic shocks to agricultural revenues. What we find is that although the full insurance model is rejected by the data, the relation between idiosyncratic shocks and consumption is consistent with a simple 2-period model of limited commitment in which households sign contracts with a moneylender in period 1 to insure consumption uncertainty in period 2. Under limited commitment, villagers can choose to renege on previously made arrangements if the cost of honoring their contract is higher than the cost of default. In this environment, second-best risk sharing contracts can however be passed in which consumption is stabilized below the village mean in case of unfavorable shocks and, at the same time, villagers can enjoy higher consumption in proportion to realized shocks in case of more favorable events.

Previous important studies have looked at the role of limited enforcement on risk sharing arrangements. In a 2-player repeated game framework, Coate and Ravallion (1993) characterize equilibrium conditions under which informal insurance arrangements exist despite the absence of formal contract enforcement means. Ligon et al. (2002) build a dynamic model in which self-insurance through savings is ruled-out and contracts are self-enforceable in the sense that in every period, agents weight the benefit of honoring the contract against the value of remaining forever in autarky. Using ICRISTAT data from three villages in India, they compare simulated data from their model to actual consumption data and they conclude that the limited commitment model goes a long way in explaining the dynamics of consumption, although it is less successful in accounting for the cross-sectional distribution of consumption. Finally, Dercon and Krishnan (2003) look at the impact of public transfers in the form of food aid on consumption in rural Ethiopia. Interestingly, they find evidence of crowding out of private transfers with idiosyncratic shocks being uninsured only in localities benefitting from public safety nets. This finding is consistent with situations were aggregate insurance is provided by the public sector in an environment where the pooling of all idiosyncratic risks is constrained by the presence of enforceability constraints (Attanasio and Rios-Rull, 2000).

In contrast to previous work on testing the full risk sharing model against a free alternative, we use a simple 2-period model of limited commitment which we borrow from Obstfeld and Rogoff (1996) to specify an alternative hypothesis against which to test the full insurance model. We use two rounds of the nationally representative Vietnam Living Standard Measurement Survey and we focus on the cross-sectional distribution of consumption to conduct our test. Using reported harvest shocks and shocks to agricultural revenues as our measure of idiosyncratic shocks, we find strong support in our data in favor of the limited commitment model.

Section 2 presents a simple model of insurance under limited commitment needed to derive testable predictions. Section 3 describes the empirical methodology, the data and the results. The role of savings and some policy implications are discussed in section 4, before the conclusion.

2 Risk Sharing Theory

2.1 Basic Setup

We present a simple theoretical framework to study the effects of limited enforcement on optimal risk sharing arrangement. We borrow the setup from Obstfeld and Rogoff (1996) who use it to analyze sovereign risk.

Consider a village economy inhabited by N *ex-ante* identical households who live for two periods, labeled 1 and 2. The representative household form preferences over a single non storable consumption good according to

$$U_1 = u(c_1) + \beta E u[c_2(\varepsilon)] \tag{1}$$

where $u(c)$ is an increasing, strictly concave, and twice continuously differentiable function, $\beta \in (0,1)$ is a discount factor and ε is an idiosyncratic shock on period 2 endowment which is independently and identically distributed across households. In period 1 households receives a certain endowment Y_1 which is entirely consumed, $c_1 = Y_1$. The only decision in period 1 is to sign a contract with the planner which acts as a moneylender to insure uncertainty on future endowment. In period 2, households receives an endowment which is given by

$$Y_2(\varepsilon_s) = \bar{Y} + \varepsilon_s \tag{2}$$

where $\bar{Y} = \frac{1}{N}\sum_{j=1}^{N} Y_2^j$, ε is a random shock to period 2 endowment, which has mean zero and is independently and identically distributed across households. The idiosyncratic shocks ε are draw from a finite set $S = \{\varepsilon_1, ..., \varepsilon_S\}$ such that $\varepsilon_1 < \varepsilon_2 < ... < \varepsilon_S$ and $\bar{Y} + \varepsilon_1 > 0$. These shocks, which are observed by everyone, are the only source of uncertainty in this village economy, and the insurance contract is the only mechanism through which villagers can transfer wealth across states[1]. Let $\pi(\varepsilon_s) = prob(\varepsilon = \varepsilon_s)$, $s = 1, ..., S$ and $\sum_{s=1}^{S} \pi(\varepsilon_s) = 1$. In this environment, the moneylender reallocates risk across villagers and offers insurance contracts in period 1 which take the form of a state contingent payment $P(\varepsilon_s)$, from households to the planner, taking place in period 2 (if $P(\varepsilon) < 0$, the payment is made from the insurer to the household). Furthermore, the moneylender

[1] In this setting, allowing for savings does not change the main predictions of the model. See section 4.

operates under the zero-expected-profit condition:

$$\sum_{s=1}^{S} \pi\left(\varepsilon_s\right) P\left(\varepsilon_s\right) = 0 \tag{3}$$

2.2 Full Insurance

Assuming that $\beta = 1$, and that both the moneylender and the household are willing to honor the contract *ex post*, the representative household will choose $c_2\left(\varepsilon\right)$ and $P\left(\varepsilon\right)$ so as to maximize his discounted expected utility:

$$\max_{\{c_2(\varepsilon);P(\varepsilon)\}} \sum_{s=1}^{S} \pi\left(\varepsilon_s\right) u\left[c_2\left(\varepsilon_s\right)\right] \tag{4}$$

such that (3) holds

$$\sum_{s=1}^{S} \pi\left(\varepsilon_s\right) P\left(\varepsilon_s\right) = 0 \tag{5}$$

together with the S budget constraints

$$c_2\left(\varepsilon_s\right) = \bar{Y} + \varepsilon_s - P\left(\varepsilon_s\right) \tag{6}$$

Since $E\left(\varepsilon\right) = 0$, the optimal insurance contract is such that $P\left(\varepsilon_s\right) = \varepsilon_s$ which implies that $c_2\left(\varepsilon_s\right) = \bar{Y}$. Under such a contract, households insure away all the risk associated with their period 2 endowment, the lucky households $\left(\varepsilon_s > 0\right)$ pay a premium to the moneylender while the unlucky ones $\left(\varepsilon_s < 0\right)$ receive a transfer from the moneylender so that at the end of the day all villagers consume the average endowment $\bar{Y}$.

2.3 Limited Commitment

Now, we assume that although the moneylender commits to honor the insurance contract, households are free to walk away from the arrangement in period 2, after the realization of shocks. For example, if the arrangement made in period 1 is the full insurance contract examined before, those villagers with $\varepsilon_s > 0$ will have an incentive to default if there are no cost of doing so. Now if we assume that the cost of default in this economy is a fraction η of period 2 endowment, $\eta \in (0, 1)$, a villager will choose to default on the insurance contract if the cost of doing so is less than the cost of sustaining the contract, that is if

$$P\left(\varepsilon_s\right) > \eta\left(\bar{Y} + \varepsilon_s\right) \tag{7}$$

Knowing that some households might face incentives to walk away from the contract in period 2, the moneylender wishes to design a contract that is incentive-compatible in the sense that villagers are induced by the structure of the contract to honor the arrangement *ex-post*, independently of the realization of ε. The incentive compatible constraint in this case is

$$P\left(\varepsilon_s\right) \leq \eta\left(\bar{Y} + \varepsilon_s\right) \tag{8}$$

for all $s = 1, ..., S$.

Assuming again that $\beta = 1$, the planner's problem is now

$$\max_{\{c_2(\varepsilon);P(\varepsilon)\}} \sum_{s=1}^{S} \pi\left(\varepsilon_s\right) u\left[c_2\left(\varepsilon_s\right)\right] \tag{9}$$

such that (3) holds

$$\sum_{s=1}^{S} \pi\left(\varepsilon_s\right) P\left(\varepsilon_s\right) = 0 \tag{10}$$

together with the S budget constraints (6)

$$c_2\left(\varepsilon_s\right) = \bar{Y} + \varepsilon_s - P\left(\varepsilon_s\right) \tag{11}$$

and the incentive compatibility condition (8)

$$P\left(\varepsilon_s\right) \leq \eta\left(\bar{Y} + \varepsilon_s\right) \tag{12}$$

The Lagrangian of the problem can be written as

$$L = \sum_{s=1}^{S} \pi\left(\varepsilon_s\right) u\left[\bar{Y} + \varepsilon_s - P\left(\varepsilon_s\right)\right] - \sum_{s=1}^{S} \lambda\left(\varepsilon_s\right)\left[P\left(\varepsilon_s\right) - \left(\bar{Y} + \varepsilon_s\right)\right] + \mu \sum_{s=1}^{S} \pi\left(\varepsilon_s\right) P\left(\varepsilon_s\right) \tag{13}$$

which yields the following first-order conditions

$$u^{'}\left[c_2\left(\varepsilon\right)\right]+\lambda\left(\varepsilon\right)=\mu \tag{14}$$

$$\lambda\left(\varepsilon\right)\left[\eta\left(\bar{Y}+\varepsilon\right)-P\left(\varepsilon\right)\right]=0 \tag{15}$$

$$\lambda\left(\varepsilon\right)\geq 0 \tag{16}$$

For low realizations of ε (bad states), the incentive compatibility constraint will as an inequality $P\left(\varepsilon\right) < \eta\left(\bar{Y}+\varepsilon\right)$ and $\lambda\left(\varepsilon\right)=0$. These are states in which there is no incentive problem for the villager, either because he receives a transfer from the moneylender, or because the payment made to the moneylender is strictly smaller than the cost of default. By (14) $u^{'}\left[c_2\left(\varepsilon\right)\right]=\mu$, so that consumption is constant and independent of realized shocks. Since consumption is constant for $\lambda\left(\varepsilon\right)=0$, (6) implies that payments can be written as $P\left(\varepsilon\right)=P_0+\varepsilon$, where $P_0=\bar{Y}-c_2$. Ultimately, the level of consumption achieved in bad states $\left(c_2=\bar{Y}-P_0\right)$ will be a function of η which sets how much the villager can promise to repay to the moneylender during good states.

As realized shocks become more favorable to the villager, one can show that there is a threshold level of shock e above which $\lambda\left(\varepsilon\right) > 0$[2] so that the incentive compatibility constraint binds. In these situations, by (16), $P\left(\varepsilon\right)=\eta\left(\bar{Y}+\varepsilon\right)$ for all ε at which $\lambda\left(\varepsilon\right)>0$, which means that in good states, payments to the moneylender are increasing in ε but at a rate $\eta<1$. Hence, in order to prevent villagers to walk away from the contract when the incentive compatibility constraint binds, the moneylender has to accept a payment that increases less with shocks than the full insurance contract payment.

By (6) this also implies that consumption in good states is increasing with realized shocks at rate $(1-\eta)$:

$$c_2\left(\varepsilon\right)=\bar{Y}+\varepsilon-P\left(\varepsilon\right)=\left(1-\eta\right)\left(\bar{Y}+\varepsilon\right) \text{ when } e<\varepsilon<\varepsilon_S \tag{17}$$

[2]From (14) and (6), we can write that $u^{'}\left(\bar{Y}-P_0\right)-u^{'}\left[c_2\left(\varepsilon\right)\right]=u^{'}\left(\bar{Y}-P_0\right)-u^{'}\left[\left(1-\eta\right)\left(\bar{Y}+\varepsilon\right)\right]=\frac{\lambda(\varepsilon)}{\pi(\varepsilon)}\geq 0$. So there is an e such that $\bar{Y}-P_0=\left(1-\eta\right)\left(\bar{Y}+e\right)$, and for $\varepsilon > e$, $\lambda\left(\varepsilon\right)$ must be strictly positive. See Obstfeld and Rogoff (1996)

The threshold value of e above which $\lambda(\varepsilon) > 0$ defines P_0 such that

$$P_0 = \eta \bar{Y} - (1 - \eta) e \tag{18}$$

So the insurance contract under limited commitment can be written as

$$\begin{aligned} P(\varepsilon) &= \eta \bar{Y} - (1-\eta) e + \varepsilon = \eta \left(\bar{Y} + e \right) + (\varepsilon - e) \ \text{ for } \varepsilon \in [\varepsilon_1, e) \\ P(\varepsilon) &= \eta \left(\bar{Y} + \varepsilon \right) = \eta \left(\bar{Y} + e \right) + \eta (\varepsilon - e) \qquad \text{ for } \varepsilon \in [e, \varepsilon_S] \end{aligned} \tag{19}$$

and consumption under this optimal risk sharing arrangement will look like

$$\begin{aligned} c_2(\varepsilon) &= (1-\eta) \left(\bar{Y} + e \right) \ \text{ for } \varepsilon \in [\varepsilon_1, e) \\ c_2(\varepsilon) &= (1-\eta) \left(\bar{Y} + \varepsilon \right) \ \text{ for } \varepsilon \in [e, \varepsilon_S] \end{aligned} \tag{20}$$

Under limited commitment, the optimal insurance contract does not equalize marginal utilities of all villagers. Villagers experiencing favorable shocks (those for which $\lambda(\varepsilon) > 0$) will have higher consumption, and their consumption level will increase with ε. On the other hand, villagers for which the incentive constraint is not binding ($\lambda(\varepsilon) = 0$) will have a constant consumption level no matter how much their shock is. These features of the optimal incentive compatible contract are represented in figure 1.

2.4 Infinite Horizon

Ljungqvist and Sargent (2004) show that a very similar contract emerges if one assumes an infinite horizon model with one-sided no commitment. In their setup, the household is forever excluded from any future risk sharing arrangement if he chooses to default once. The incentive compatibility constraint is then that the moneylender must offer to the villager in every period at least the autarky value of his future streams of endowment. A recursive formulation of this problem is possible by defining the promised expected discounted future utility as the appropriate state variable of the problem. At every period t, before the realization of ε, the moneylender delivers the value v_t that was promised at period $t-1$ by letting c_t and the continuation value v_{t+1} react to the realized endowment Y_t. Similarly to the previous setting, when the participation constraint does not bind (i.e when the future expected utility of sticking to the contract is equal or above the future expected value of autarky), the moneylender delivers a level of consumption that is independent of ε. When the participation constraint binds however, the moneylender trades with the villager a level of consumption that is below his current period endowment against the promise of a higher future expected value υ_{t+1}. In this case, consumption raises with unexpected shocks to the endowment, but less than one to one.

With these features in mind, we now turn to the data and describe the empirical methodology to test for risk sharing among Vietnamese farmers.

2.5 Econometric Specification

Much of the previous applied work related to risk sharing tests in village economies was based on testing the null hypothesis of full insurance against an unspecified alternative hypothesis. Our strategy instead is to also compare the full insurance outcome with a specified alternative under limited commitment. We will first present here the benchmark test equation of full insurance and then an alternative specification based on the limited commitment model outlined above.

Under the null of full risk pooling, we saw in the previous section that all idiosyncratic shocks to income should be irrelevant for consumption. This gives rise to the following regression test which has been commonly implemented since Cochrane (1991), Mace (1991) and Townsend (1994):

$$c_t^j = \alpha + \beta_1 C_t^A + \beta_2 X_t^j + \beta_3 \varepsilon_t^j + \eta^j + \upsilon_t^j \tag{21}$$

where c_t^j is a measure of household consumption and C_t^A is the average consumption at village level which accounts for all aggregate shocks. X_t^j is a vector of household characteristics designed to capture observable heterogeneity in tastes due to differences in composition and age of household members for example, and η^j is a household fixed effect which captures unobserved time-invariant heterogeneity in consumption. ε_t^j is an idiosyncratic shock variable to income. Finally, υ_t^j is a random disturbance term which is assumed to have mean zero and to be identically distributed across households. We assume that these errors are independently distributed across villages, but not necessarily across households within villages. This baseline specification can be derived from the first order conditions of a planner's problem where the planner maximizes a sum of weighted CARA utilities under a village level aggregate resource constraint[3]. Under the null hypothesis of perfect risk pooling, $\beta_1 = 1$ and $\beta_3 = 0$. Since household effects η^j are not observable, and if at least 2 periods are available, then taking the first difference of (21) removes the fixed effects and the β parameters can be consistently estimated by OLS. Ravallion and Chauduri (1997) show however that if shocks are not purely idiosyncratic OLS estimates are consistent only under the null of $\beta_3 = 0$. If instead $\beta_3 > 0$ and if there is also a common component in ε_t^j (for example if the variable used is total income, which has both a common and an idiosyncratic part), then $\hat{\beta}_3^{OLS}$ will be biased downward. Ravallion and Chauduri (1997) propose an alternative specification to (21) for which parameters are consistently estimated by OLS both under the null and the alternative:

$$c_t^j = \alpha + \sum_{t=1}^{T}\sum_{c=1}^{C} \gamma_{ct}\delta_{ct} + \beta_2 X_t^j + \beta_3 \varepsilon_t^j + \eta^j + \upsilon_t^j \tag{23}$$

where δ_{ct} is a dummy variable equal to 1 if household j belongs to commune c at time t and 0 otherwise. The difference between (21) and (23) stems from the fact that the use of village-year dummy variables allows to completely separate the aggregate risk from idiosyncratic effects in (23). To compare our results with the previous literature, we use both specifications to test the full risk sharing model.

Besides however, as Morduch (2002) noticed, while inability to reject the null hypothesis of full insurance is informative, rejecting the benchmark model when several alternatives are possible is less so. In this paper we will work with shock variables that are continuously distributed and can take both positive and negative values. This allows us to distinguish the effect of favorable shocks from unfavorable ones, and by doing so we are able to test the full insurance allocation against a specified alternative derived from the simple model of limited commitment examined in the previous section. Under the alternative hypothesis of limited commitment, a direct implication of (20) is that

$$\begin{aligned} \beta_1 &\leq 1 \text{ and } \beta_3 = 0 \text{ for unfavorable } \varepsilon_t^j \\ \beta_1 &\leq 1 \text{ and } \beta_3 > 0 \text{ for favorable } \varepsilon_t^j \end{aligned}$$

[3]If one assumes CRRA utility, we have instead the following specification:

$$\log c_t^j = \alpha + \beta_1 \log C_t^A + \beta_2 X_t^j + \beta_3 shock_t^j + \eta^j + \upsilon_t^j \tag{22}$$

Using this alternative specification did not change our results.

where we take positive shocks to income as being favorable and negative shocks as unfavorable.

2.6 The Data

2.6.1 Survey Design

The Vietnam Living Standard Surveys (VLSS) are two household surveys conducted in 1992/93 and 1997/98 by the General Statistical Office (GSO) of Vietnam[4]. The questionnaires were designed to cover a wide range of areas related to living standards and economic activity, with a particular emphasis on consumption and agricultural production.

Both surveys provide comparable, good quality, and representative data at the national level. In both years, the survey is a stratified random sampling conducted in three stages. The sample size is 4800 households in 1992/93, 5999 households in 1997/98, and 4000 households were interviewed in both surveys. The overall sampling frame was stratified into two groups, urban (20% of the population) and rural, and sampling was carried out separately in each strata. In these two groups, 150 communes were randomly selected in order to represent all provinces of Vietnam (first stage). Out of these 150 communes, 120 were from rural areas. In each commune, 2 villages were randomly chosen (second stage), and in each village about 20 households were randomly chosen for interviews (third stage).

In this paper, we focus on rural households for which agriculture is the main activity and who were interviewed in both waves.

2.6.2 Consumption data

Consumption expenditures are available at a high level of disaggregation. Consumption data include food expenditures and non food expenditures. Food expenditures are collected over 45 food items by a variable-recall procedure procedure[5]: for each items, household members are asked about quantity

[4]These surveys were part of the Living Standard Measurement Study (LSMS) surveys taking place in many developing countries with technical assistance from the World Bank.

[5]In theory, a variable-recall procedure in which the frequency of purchases varies across items and respondents, should provide more accurate expenditure information than a constant-recall procedure such as asking for expenditure information for the month preceding the date of interview. But a variable-recall procedure is also more demanding, both for the interviewer and the respondent. Beside, it requires checking the data to see if the various parts are consistent with each other. Many checks were performed on the raw data minimize inconsistencies and recording errors.

and value of purchases, the number of months during the year for which items were bought, and the frequency of purchases during these months. In addition to annual market purchases, the value of home production consumed during the year is also computed. Non-food expenditures include daily expenses, annual expenditures, expenditures on consumer durables, expenditures from utilities (water, electricity, etc.) and housing expenses.

For the purpose of this paper we focus on three consumption aggregates to study consumption risk sharing: total consumption expenditures, non-durable expenditures, and food expenditures. For each of these aggregates, we look at expenditures per adult equivalent [6] Variables are all expressed in real terms at 1998 prices and adjusted for monthly and regional price variations.

2.6.3 Shock variables

We use two measures of idiosyncratic shocks to income derived from our data. The first one is based on reported shocks to harvest at household level and the second is the residual from an estimated agricultural production function.

- Harvest shocks

The VLSS data provide a very detailed account of agricultural activity at the household level. Information is available for every cultivated crops on the type of land, the soil quality and the various inputs and equipment used. In 1998, households were asked crop by crop how much was their harvest (in kg) compared to normal years[7]. We use this information to build an idiosyncratic shock variable measuring shocks to harvest value.

It is common that households cultivate many crops at the same time. The median number of crops cultivated is 5. Rice is the main cultivated crop and accounts for 40% of all cultivated crops. The rest of the growing activity is mostly devoted to corn, sweet potatoes and various vegetables.

For every crop grown, household had to report the quantity harvested and how much would that quantity represent compared to a normal year. We convert the quantities harvested for different crops in monetary unit using market crop prices at the local level. Then, monthly and regional price indices are used to convert harvest values in real terms. Table 1a and 2a describe the distribution of harvest

[6] We use adult equivalent scales that were calculated for Vietnam from the same data White and Masset (2002).
[7] Unfortunately, this information was not included in the VLSS 1993.

shocks. About 98% of households experienced either positive or negative shocks to their potential normal harvest value and approximately 85% of these shocks are contained within a magnitude of +/- 20%. On average, realized harvest 1998 was 6% below normal years. Negative shocks averaged to -11% an positive shocks to 4%. Figure 2 shows the regional dispersion in harvest shocks. In all the seven administrative regions, even if some household experienced positive shocks, most of them had harvest below normal year level.

An important issue if we want to assess the extent of commune-level risk sharing is the degree of idiosyncrasy in shock variables. Even if harvest shocks are reported at the household level, it is highly likely that an important part of their variation is common across communes. Including commune dummies in our regressions will disentangle the aggregate component of shocks from their idiosyncratic part, but we still need to know how much of these shocks can be considered genuinely idiosyncratic. The first thing we do in order to address this issue is a simple variance decomposition exercise by regressing harvest shocks on commune dummies. This tells us that 25% of the variation in harvest shocks are accounted for at the village level, which still leaves a fair amount of variation unexplained by the common commune component. To complement this variance decomposition, we also look at the coefficient of variation of harvest shocks at the commune level. The coefficient of variation ranges from 2% to 60%. Except five communes (out of 120) where the individual variation around the communal mean is relatively low, around 2-5%, on average across the country the magnitude of variation for harvest shocks is about +/-17% around their mean. . Figure 3 presents the regional averages of commune level coefficients of variation for these shocks. Overall, we can say that there is reasonable degree of idiosyncratic variation in harvest shocks to study risk sharing arrangements at the commune level.

Another issue we need to address when using harvest shocks to estimate (21) or (23) is that reported harvest shocks are only available in the second round of the survey (1998). This forbids us to directly take the first difference of (21) or (23) in order to control for fixed effects. We proceed instead in two steps. First, we run a fixed-effects regression from (21) without the shock variable ε_t^j and we compute the fixed effects by

$$\hat{\eta}^j = \alpha + \hat{\beta}_1^{FE} C_t^A + \hat{\beta}_2^{FE} X_t^j + \upsilon_t^j - c_t^j \tag{24}$$

Keeping in mind though that these fixed effects are consistently estimated only under the null of $\beta_3 = 0$, we use the estimated $\hat{\eta}^j$ as regressors in the cross sectional equation (21) or (23) to test for risk sharing.

Since we are using estimated fixed effects as regressors in our risk sharing equation tests, OLS standard errors are going to be invalid (Pagan, 1984). To address this issue we use the fact that our sample is representative of the population at the national level and we use bootstrap methods (Efron and Tibshirani, 1994) to explicitly take into account the presence of generated regressors. Each bootstrap replication is a reshuffling with replacement of our original sample of farmers. For each of these replications, fixed effects are estimated in a first stage and used as regressors in the second stage to test risk sharing.

- Shocks to farm revenues

Harvest shocks only affect agricultural income derived from annual cropping activities. Farmers in our sample however also engage in perennial cropping, livestock raising and water-culture activities. Since the dataset contains detailed information on cultivated surface, hours worked on farm and various inputs used for production, we also choose to construct a shock variable on overall agricultural revenue in complement to reported harvest shocks. We assume a Cobb-Douglas production function given by

$$\log Y_{it} = \alpha + \sum_{k=1}^{K} \beta_k \log X_{kit} + \gamma \varphi_{it} + \sum_{t=1}^{T} \sum_{c=1}^{C} \lambda_{ct} \delta_{ct} + \phi_i + \epsilon_{it} \tag{25}$$

where Y_{it} is the real value of household agricultural revenue, X_{kit} are k inputs to the production function, and ϕ_i is a fixed-effect capturing heterogeneity across households such as unobserved ability but also time invariant commune characteristics such as soil conditions and other geographic characteristics influencing production. δ_{ct} are commune-year characteristics which are meant to capture time-varying common conditions or shocks to households production function. ϵ_{it} is a mean zero error term which is identically and independently distributed across households. We use ν_{it} as a measure of idiosyncratic shock to the household production function. Input variables X_{kit} include cultivated land surface, hired labor expenses, hours worked on farm by the household members, the value of capital equipment used for production and the value of various input expenditures such as seeds, fertilizers, insecticides, transport and storage. We also include a measure of technical efficiency φ_{it} in the regression, where technical efficiency is obtained after estimating a stochastic frontier production function following Battese and Coelli (1995). In this specification, technical efficiency effects are an explicit function of household-specific variables and are allowed to vary in time. The stochastic frontier model can be written as

$$\log Y_{it} = \alpha + \sum_{k=1}^{K} \beta_k \log X_{kit} + (\nu_{it} - u_{it}) \tag{26}$$

where Y_{it}, X_{kit} are as defined earlier, $\nu_{it} \sim iid\left(0, \sigma_v^2\right)$ and are independent of the u_{it} which are non-negative random variables accounting for technical efficiency in farm production. u_{it} measures the distance to the efficient stochastic production frontier given by $\alpha + \sum_{k=1}^{K} \beta_k \log X_{kit} + \nu_{it}$. We assume that u_{it} are independently distributed as truncation at zero of the $N\left(m_{it}, \sigma_u^2\right)$ distribution, where

$$m_{it} = z_{it}\delta \tag{27}$$

where z_{it} are p household-specific variables influencing farm efficiency. In our case, z_{it} contains information on the number of crops owned by the household, the age and education of the household head, and the size and composition of the household. Our estimated measure of technical efficiency to be included in (25) is thus given by

$$\hat{\varphi}_{it} = \exp\left(-u_{it}\right) \tag{28}$$

The stochastic frontier model is estimated by maximum likelihood and a summary of the technical efficiency measures is given in table 3. On average, farming technical efficiency has increased from 68% to 75% between 1993 and 1998. This comes as no surprise since during the 1990's Vietnam has experienced a period of relative macroeconomic stability with high growth, which was attributed to a set of major economic reforms implemented at the end of the 1980's. Amongst these reforms was the liberalization of agricultural sector prices (for both inputs and outputs), the de-collectivization of land property, and easier access to high-yield crop varieties through governmental subsidies.

Results from the production function estimation (25) are reported in table 4. Our specification for the production function is able to explain most of the observed variation in agricultural revenues. Our sample is mainly composed of small scale family farms engaging in cropping and livestock raising. The estimated production function for these farmers exhibit decreasing returns to scale, with land surface and input expenditures (in seeds, fertilizers, insecticides and services) contributing the most to the agricultural revenues.

We use the estimated residuals to construct shock variables for agricultural revenues as

$$exp(\hat{\epsilon}_{it})/\hat{Y}_{it} \tag{29}$$

The distribution of these shocks is summarized in table 1B and 2b. The mean of shocks to agricultural revenues is +0.62% over the two rounds, and 80% of these shocks range between -12% to +13%. Negative shocks are -7.5% on average against +8.8% for positive shocks. Since we controlled for commune dummies in the estimation of (25) we interpret ϵ_{it} as true idiosyncratic shocks to agricultural revenues. We now turn to the results from the risk sharing test equations.

2.7 Results

2.7.1 Full Insurance

We first test the full insurance model against an unspecified alternative following (21) and (23). When working with harvest shocks, we begin by estimating the consumption fixed effects in a first stage because information on harvest shocks is only available for the second round of the survey (1998). These household-specific effects are consistently estimated according to (24) provided that $\beta_3 = 0$ in (21) or (23). The age dependency of the household is included in the regressions to control for taste heterogeneity related to the age structure and composition of households[8]. In a second stage, we run OLS regressions for (21) and (23) allowing for intra-group correlation of errors at the commune level[9]. Results are reported in table 5a. for (21) and in table 5b. for (23) where village

[8] The age-dependency variable is the ratio of members aged below 15 and above 65 over members aged between 15 and 65. Estimated coefficients were not reported in the tables for space consideration. All estimated coefficients were significantly negative at conventional confidence level.

[9] In the reported results, the coefficient for the fixed-effect term is estimated. Imposing a restriction on this coefficient to equal one did not change our results.

dummies are included instead of aggregate commune consumption. These results show that even though harvest shocks are positively associated with household consumption, this association vanishes when we control for aggregate commune consumption. Focusing on total consumption first, the estimated coefficient $\hat{\beta}_3$ is not different from zero (column (3)), suggesting that idiosyncratic harvest shocks are insured at the commune level, and also that the fixed effects $\hat{\eta}^j$ are consistently estimated. The full insurance model is however rejected as the aggregate commune consumption coefficient $\hat{\beta}_1$ is significantly below 1. These results hold also for non-durable consumption (column (6)) and for food consumption (column (9))[10]. Turning to table 5b., we can see that including commune dummies instead of aggregate commune consumption brings similar results. Overall, it is surprising to see how close we get to the complete risk-pooling model, even if on average household consume slightly less than the village mean, in contradiction with the full insurance allocation.

Even if crop income is a major component for Vietnamese farmers in our sample, it is not the only one. Beside annual cropping activities for which information on harvest shocks is available, farmers income is also derived from perennial cropping activities (fruits, tea, coffee), livestock raising, and aquaculture. This is why we also look at the effect of idiosyncratic shocks to total agricultural revenues on consumption. Results from the test of full risk-sharing against a free alternative are reported in columns (1), (3) and (5) of table 7a. and table 7b. In contrast with harvest shocks, idiosyncratic shocks to agricultural revenues have a significant impact on total consumption and on non-durable consumption. Only food consumption seems to be protected from the influence of production shocks. For all the three consumption measures considered however, the full insurance outcome is rejected by the data given that here again, farmers consume on average less than the commune mean.

These results are consistent with previous findings in similar environment and also in more developed countries, rejecting the strict version of the full insurance model. We pursue however the analysis in testing the full insurance model against a specified alternative hypothesis consistent with optimal risk sharing under limited commitment.

2.7.2 Limited Commitment

[10]Results (not reported) are also robust to an alternative specification of (21) and (23) with variables expressed in logarithm instead of level. This alternative specification is consistent with CRRA preferences instead of the CARA form.

Since our shock variables are continuously distributed and take both positive and negative values, we are able to test a central prediction of the simple risk sharing model with limited commitment. The full insurance model predicts that both positive and negative idiosyncratic shocks to income should be inconsequential for consumption. Under limited commitment however, the optimal risk sharing arrangement is one in which unfavorable shocks are insured but consumption remains below the village average. In contrast, households hit by favorable shocks should see their consumption level increase with the level of these shocks. We choose to separate negative shocks from positive ones to test this prediction.

Results for harvest shocks are reported in table 6a. and 6b. for regressions including aggregate commune consumption. Negative shocks have a negative impact on consumption, but the coefficient is not statistically different from zero when we control for aggregate commune consumption. Besides, the coefficient for aggregate commune consumption is estimated to be below one. Moreover, turning now to positive shocks, we see that these affect consumption positively and significantly. This pattern holds for the three consumption measures considered, bringing strong support to the risk sharing model under limited commitment. Table 6c. and table 6d. give similar results when we include commune dummies instead of aggregate commune consumption: negative shocks are insured but positive shocks have a significant positive impact on consumption, except for food consumption where the estimated coefficient is not different from zero.

Turning finally to production shocks, we also obtain very similar results (table 7a. and table7b.). The impact of negative shocks to consumption levels is not different from zero. In contrast, households hit by positive shocks enjoy higher consumption level. With production shocks, this pattern holds for total consumption and for non-durable consumption. Food consumption on the other hand seems to be unaffected by both negative and positive shocks, suggesting that as far as food consumption is concerned, our data come very close to the perfect insurance model. But still, households hit by positive shocks consume on average a higher share of village mean consumption (table 7a, column (9)).

Overall, our data provide some support to an environment where risk sharing arrangements are taking place at the commune level under limited commitment. In this environment, the Pareto-optimal full insurance contract cannot be offered because villagers hit by favorable shocks are facing *ex-post* incentives to renege on their arrangement with the village moneylender. If sanctions can be imposed by the moneylender, a second-best arrangement can however be reached, by insuring those villagers hit by unfavorable shocks and giving them a consumption level below the village mean while on the other hand, allowing households hit by favorable shocks to consume more in proportion to the level of shocks.

3 Discussion

3.1 Savings

The simple model sketched out in section 2 ruled out the possibility of savings. Self-insurance through savings is however likely to be an important mechanism through which villagers could insure away part of their income risk. In fact, introducing the possibility for household to store part of their period 1 endowment in the picture does not alter the model's prediction concerning the shape of period 2 consumption relative to the level of idiosyncratic shocks under the limited commitment hypothesis. If we assume that villagers can borrow and lend in period 1 at rate $r > 0$ such that $\beta(1 + r) = 1$, the crucial assumption we need to make in order to maintain the model's main predictions is that savings act as a collateral that can be seized by the moneylender in case of default. The villager now chooses c_1 and $P(\varepsilon)$ to maximize

$$U_1 = u(c_1) + \beta \sum_{s=1}^{S} \pi(\varepsilon_s) u[c_2(\varepsilon_s)] \tag{30}$$

such that

$$c_2(\varepsilon_s) = \bar{Y} + \varepsilon_s - P(\varepsilon_s) + (1 + r)\left(\bar{Y} - c_1\right) \tag{31}$$

and the incentive compatibility constraint

$$P(\varepsilon_s) \leq \eta\left(\bar{Y} + \varepsilon_s\right) + (1 + r)\left(\bar{Y} - c_1\right) \tag{32}$$

Absent incentives problems, the full insurance contract still delivers the optimal allocation stabilizing villagers consumption at $\bar{Y}$ in both periods. Under limited commitment, a partial insurance contract similar to the case without savings emerges, where consumption in period 2 is stabilized below the commune mean consumption for unfavorable realizations of shocks, and it increases with favorable realizations of shocks. In this case however, partial insurance is also achieved through accumulated savings from period 1, directly by allowing villagers to consume more in period 2 in case of bad shocks, and indirectly by allowing easier access to risk-sharing arrangements through higher collateral.

3.2 Policy Implications

The optimal risk sharing arrangement under limited commitment is a partial insurance contract that is Pareto dominated by the full insurance allocation. In this situation, the possibility for governments to enhance welfare by providing more insurance through the provision of public social safety nets for example is not straightforward. Attanasio and Rios-Rull (2000) have studied the case of aggregate insurance schemes in a dynamic setting where contracts are self-enforcing. In a dynamic setting, agents weight every period the cost of complying with the terms of the contract to the cost of leaving the arrangement. Under such environment, additional aggregate insurance provided by the state might simply deter potential informal risk sharing arrangements from taking place by increasing the value of autarky. In particular cases, this crowding-out effect of private transfers might lead to welfare losses. The net welfare effect of public intervention in this environment is therefore *a-prior*i ambiguous. Dercon and Krishnan (2003) look at the impact of food aid program on consumption in rural Ethiopia. They find some evidence in line with this crowding-out effect of risk-sharing arrangements under a limited commitment. Their results show that idiosyncratic shocks to income are less well insured in localities with safety nets.

4 Conclusion

In this paper, we have looked at an environment where income risk is relatively important due to the uncertain nature of agricultural activities, and where formal insurance contracts to insure away these risks are weak or absent. Despite the absence of such formal insurance contracts, agents can however engage into risk-sharing arrangements at the commune level to dissipate idiosyncratic shocks to income. Focusing on reported harvest shocks and on shocks to agricultural revenues among Vietnamese farmers, we found that adult equivalent consumption levels are insured from negative shocks and at the same time they increase with positive shocks. These findings are consistent with optimal risk sharing arrangements taking place at the village level in an environment where contracts are not enforceable *ex-post*. In such an environment, assuming that moneylenders can seize only a fraction of villagers' output in case of default, the optimal contract is one in which consumption is stabilized below the village aggregate level in case of unfavorable realizations of shocks, and where in case of more favorable events, villagers can enjoy higher consumption in proportion to their realized shocks.

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Tables

Table 1a. Harvest Shocks (in % of normal harvest)

	All Shocks	**Neg. Shocks**	**Pos. Shocks**
N	**2965**	**2100**	**807**
Min	-99.16	-99.16	0.04
Max	85.71	-0.02	85.71
Mean	-6.29	-10.56	4.36
Median	-2.12	-5.57	2.07
St. dev	13.48	13.18	7.20
Decile 1 (10%)	-23.12	-27.64	0.01
Decile 9 (90%)	3.73	-0.01	11.43

Table 1b. Production Shocks (in % of production frontier)

	All Shocks	**Neg. Shocks**	**Pos. Shocks**
N	**5726**	**3019**	**2707**
Min	-63.79	-63.79	0.00
Max	176.17	0.00	176.17
Mean	0.62	-7.52	8.76
Median	0.00	-5.95	6.33
St. dev	11.49	6.43	9.50
Decile 1 (10%)	-11.77	-31.23	0.10
Decile 9 (90%)	13.34	-0.10	45.42

Table 2a. Harvest Shock Distribution

(N = 2965)	Percentage of Observations
No shock	1.96
Positive Shocks	27.22
Negative Shocks	70.83
Shocks in [-5% ; +5%]	54.46
Shocks in [-10% ; +10%]	72.44
Shocks in [-20% ; +20%]	86.31

Table 2b. Production Shock Distribution

(N = 5726)	Percentage of Observations
No shock	0
Positive Shocks	47.3
Negative Shocks	52.7
Shocks in [-5% ; +5%]	28.76
Shocks in [-10% ; +10%]	52.41
Shocks in [-20% ; +20%]	82.33

Table 3. Technical Efficiency (in % of production frontier)

Farming Efficiency, Mean and Variation (%)

	1993		1998	
	mean	**variation**	**mean**	**variation**
Whole Country	**68.1**	*23.1*	**74.8**	*17.6*
Norther mountains	75.9	*14.8*	78.0	*14.3*
Red River Delta	70.1	*17.9*	75.5	*15.5*
North Central Coast	67.7	*19.0*	76.2	*14.9*
South Central Coast	63.3	*30.5*	75.0	*16.0*
Central highlands	68.3	*25.6*	73.4	*21.1*
Southeast	55.8	*37.3*	69.1	*25.1*
Mekong River Delta	63.7	*26.2*	70.8	*22.1*

Table 4. Production Function Estimates (Fixed Effects)

Dependent: Log of Agricultural Revenues			
$(N = 2863; T = 2)$	(1)	(2)	(3)
Land Surface (m^2)	.21***	.20***	.19***
	(.03)	(.01)	(.01)
Irrigated Land Surface (m^2)	.03***	.02***	.01***
	(.007)	(.002)	(.002)
Hired Labor Expenses	.02**	.02***	.02***
	(.008)	(.003)	(.002)
Hours Worked on Farm	.02	.06***	.06***
	(.02)	(.003)	(.006)
Input Expenditures	.22***	.20***	.20***
	(.03)	(.01)	(.008)
Capital Equipment Value	.06***	.05***	.04***
	(.005)	(.002)	(.002)
Technical Efficiency (%)		3.71***	3.62***
		(.06)	(.06)
Commune-Year Dummies	No	No	Yes
R^2	.4	.91	.93

Table 5a. Full Risk Sharing:

Harvest Shocks and Aggregate Commune Consumption

Cross-section OLS with estimated fixed-effects

$N = 2965$	**Total Cons.**			**Non Durables**			**Food Cons.**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Harv. Shock	10.78***	6.17**	2.05	7.70***	4.56*	1.81	4.71***	3.24**	1.84
	(3.00)	(2.92)	(1.75)	(2.56)	(2.60)	(1.57)	(1.26)	(1.51)	(1.19)
Fixed Effect		1.02***	1.11***		.97***	1.03***		.80***	.82***
		(.07)	(.07)		(.10)	(.09)		(.16)	(.16)
Commune Cons.			.94***			.93***			.89***
			(.02)			(.03)			(.02)
R^2	.03	.53	.78	.03	.49	.73	.01	.4	.57

Age dependency ratio is included in regressions but coefficients are not reported.

Standard errors are bootstrapped to account for the presence of a generated regressor (1000 replications).

Table 5b. Full Risk Sharing:

Harvest Shocks and Commune Dummies

Cross-section OLS with estimated fixed-effects

$N = 2965$	**Total Cons.**			**Non Durables**			**Food Cons.**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Harv. Shock	10.78***	6.17**	2.96	7.70***	4.56*	2.56	4.71***	3.24**	2.64
	(3.28)	(3.02)	(2.11)	(2.53)	(2.48)	(1.95)	(1.25)	(1.51)	(1.68)
Fixed Effect		1.02***	1.08***		.97***	1.01***		.80***	.81***
		(.07)	(.06)		(.09)	(.09)		(.17)	(.16)
Commune Dummies	No	No	Yes	No	No	Yes	No	No	Yes
R^2	.03	.53	.8	.03	.49	.75	.01	.4	.6

Age dependency ratio is included in regressions but coefficients are not reported.

Standard errors are bootstrapped to account for the presence of a generated regressor (1000 replications).

Table 6a. Risk Sharing Under Limited Commitment:
Negative Harvest Shocks and Aggregate Commune Consumption

Cross-section OLS with estimated fixed-effects

$N = 2100$	**Total Cons.**			**Non Durables**			**Food Cons.**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Neg. Shocks	-11.21***	-7.60**	-2.07	-8.09**	-5.55*	-1.84	-5.18***	-3.81*	-2.24
	(4.03)	(3.70)	(2.33)	(3.40)	(3.22)	(2.24)	(1.59)	(2.04)	(1.66)
Fixed Effect		1.02***	1.10***		.98***	1.04***		.83***	.85***
		(.09)	(.08)		(.12)	(.12)		(.20)	(.20)
Commune Cons.			.95***			.94***			.89***
			(.03)			(.03)			(.04)
R^2	.03	.52	.78	.03	.49	.73	.01	.41	.57

Age dependency ratio is included in regressions but coefficients are not reported.

Standard errors are bootstrapped to account for the presence of a generated regressor (1000 replications).

Table 6b. Risk Sharing Under Limited Commitment:
Positive Harvest Shocks and Aggregate Commune Consumption

Cross-section OLS with estimated fixed-effects

$N = 807$	**Total Cons.**			**Non Durables**			**Food Cons.**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pos. Shocks	5.18	4.60	6.20***	4.14	3.89	5.61***	2.48	3.20	3.47*
	(7.10)	(4.70)	(2.22)	(5.94)	(4.20)	(1.93)	(4.08)	(2.90)	(1.86)
Fixed Effect		1.08***	1.14***		.95***	1.02***		.70***	.72***
		(.08)	(.08)		(.10)	(.10)		(.15)	(.14)
Commune Cons.			.94***			.92***			.89***
			(.04)			(.04)			(.06)
R^2	.02	.55	.79	.03	.47	.73	.01	.34	.58

Age dependency ratio is included in regressions but coefficients are not reported.

Standard errors are bootstrapped to account for the presence of a generated regressor (1000 replications).

Table 6c. Risk Sharing Under Limited Commitment:

Negative Harvest Shocks and Commune Dummies

Cross-section OLS with estimated fixed-effects

$N = 2100$	**Total Cons.**			**Non Durables**			**Food Cons.**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Neg. Shocks	-11.21***	-7.60**	-2.46	-8.09**	-5.55*	-2.12	-5.18***	-3.81**	-2.68
	(4.07)	(3.67)	(2.93)	(3.31)	(3.20)	(2.73)	(1.52)	(1.87)	(2.19)
Fixed Effect		1.02***	1.07***		.98***	1.02***		.83***	.83***
		(.09)	(.09)		(.11)	(.11)		(.20)	(.19)
Commune Dummies	No	No	Yes	No	No	Yes	No	No	Yes
R^2	.03	.52	.8	.03	.49	.76	.01	.41	.61

Age dependency ratio is included in regressions but coefficients are not reported.

Standard errors are bootstrapped to account for the presence of a generated regressor (1000 replications).

Table 6d. Risk Sharing Under Limited Commitment:

Positive Harvest Shocks and Commune Dummies

Cross-section OLS with estimated fixed-effects

$N = 807$	**Total Cons.**			**Non Durables**			**Food Cons.**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pos. Shocks	5.18	4.60	5.59**	4.14	3.89	4.61**	2.48	3.20	2.57
	(6.85)	(4.46)	(2.42)	(6.00)	(4.21)	(2.03)	(4.26)	(2.94)	(1.97)
Fixed Effect		1.08***	1.10***		.95***	.98***		.70***	.69***
		(.09)	(.08)		(.10)	(.10)		(.15)	(.15)
Commune Dummies	No	No	Yes	No	No	Yes	No	No	Yes
R^2	.02	.55	.84	.03	.47	.79	.01	.34	.67

Age dependency ratio is included in regressions but coefficients are not reported.

Standard errors are bootstrapped to account for the presence of a generated regressor (1000 replications).

Table 7. Production Shocks and Aggregate Commune Consumption

Panel Fixed-Effects

	Total Cons.			**Non Durables**			**Food Cons.**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Shock to Production	4.13***			3.24***			.96		
	(1.41)			(1.21)			(.69)		
Neg. Shocks to Prod.		5.72			4.05			1.22	
		(5.24)			(4.37)			(3.01)	
Pos. Shocks to Prod.			5.65*			4.66*			.72
			(3.32)			(2.80)			(1.29)
Commune Cons.	.95***	.82***	.97***	.95***	.82***	.96***	.86***	.69***	.92***
	(.05)	(.07)	(.08)	(.05)	(.07)	(.10)	(.09)	(.10)	(.20)
Obs.	5726	3019	2707	5726	3019	2707	5726	3019	2707

Age dependency ratio is included in regressions but coefficients are not reported.

Standard errors are bootstrapped to account for the presence of a generated regressor (1000 replications).

Figures

Figure 1. Optimal Contract Under Limited Commitment

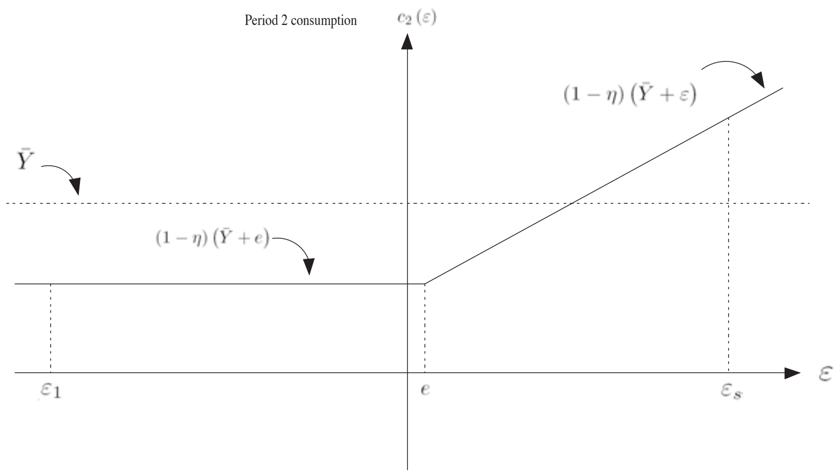

Figure 2. Harvest Shocks Magnitude by Regions

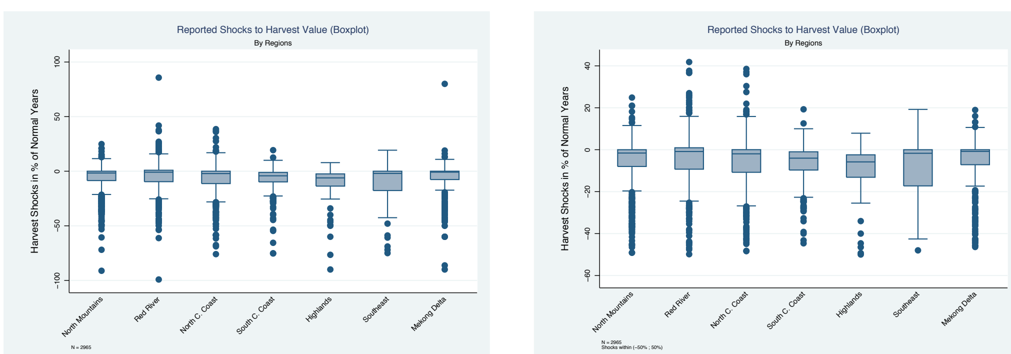

Figure 3. Harvest Shocks Variation by Regions

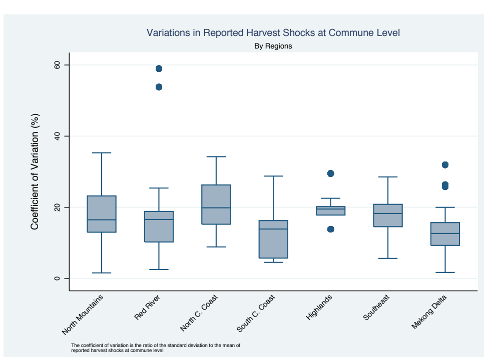

Figure 4. Harvest Shocks

Reported Harvest Shocks: Magnitude and Variation at Commune Level

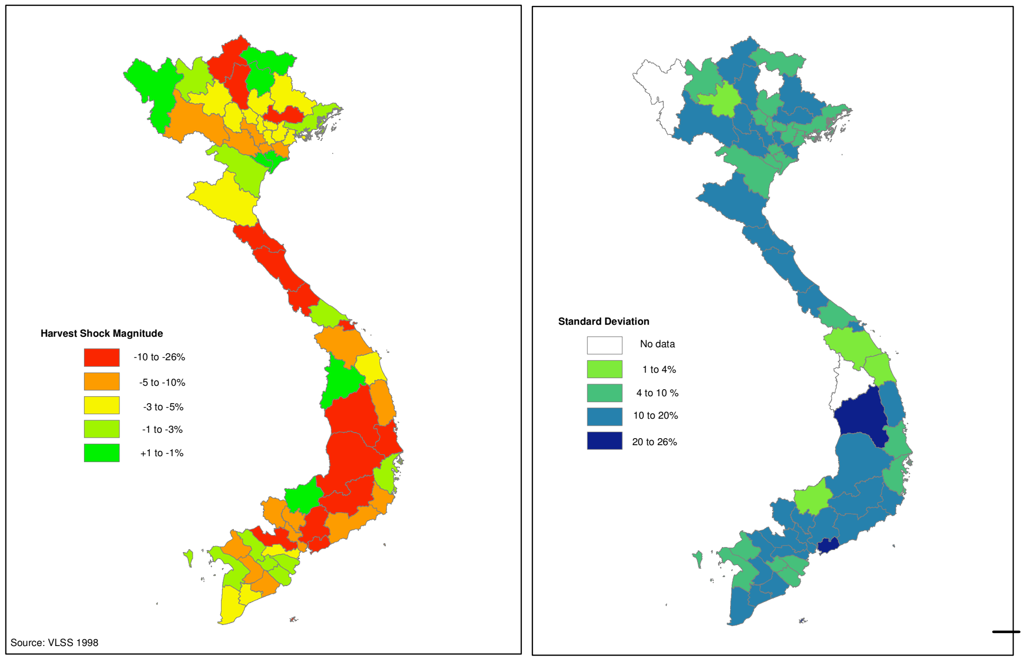

Figure 5. Agricultural Revenue Shocks

Shocks to Agricultural Revenues: Magnitude and Variation at Commune Level