Heterogeneity of Preferences, Limited Commitment and Coalitions: Empirical Evidence on the Limits to Risk Sharing in Rural Pakistan

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Abstract

In this paper, we study the determinants of the value of informal risk sharing groups. In particular, we look at the effects of heterogeneity of preferences and of limited commitment constraints that restrict feasible allocations differently if individuals can deviate form risk sharing agreements in coalitions or not. We test empirically several predictable implications in rural Pakistan taking into account the heterogeneity of households' preferences. Our results show that exogenous size of risk sharing groups can be rejected or that only imperfect risk sharing is obtained within the village because of limited commitment and because of the risk of coalition formation that needs to be deterred.

Key words: risk, insurance, risk aversion, limited commitment, coalitions, Pakistan.

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1 Introduction

Economic theory tells that with uncertainty and under complete markets, Pareto efficiency requires that agents' consumption should be fully insured against idiosyncratic income shocks. Wilson (1968) shows that individual consumption commoves positively with aggregate consumption according to the ratio of absolute risk tolerance of an agent over the sum of absolute risk tolerance of all agents. When agents have homogeneous preferences, the symmetric Pareto efficient allocation giving the same weight to each agent requires that aggregate endowment be shared equally between agents. However, empirical tests of consumption insurance seem to reject full risk sharing (Mace 1991, Cochrane 1991, Townsend 1994, Grimard, 1995, Jalan and Ravallion, 1999, Dubois, 2000). In less developed economies where income risk and random shocks are clearly very important for individuals, the problem of risk sharing is a main issue. The problem of commitment is actually stringent for the implementation of the full risk sharing allocations since the sharing of aggregate resources requires the best endowed agents to divide their revenue with less endowed agents. Ex ante, with not perfectly correlated incomes, everyone ought to commit to implement full risk sharing after realization of idiosyncratic shocks. However, ex post, lucky agents have high incentives to deviate from these promised transfers. Therefore, the enforcement of committed arrangements is crucial for ex post efficiency. If formal commitment is not possible, the repetition of these relationships between agents may make risk sharing possible (Coate and Ravallion, 1993, Kimball 1988). Actually, the subgame perfect equilibrium in pure strategies of the infinitely repeated game with threats of reversion to autarchy (which constitutes the minmax value of the game) enables to enforce some risk sharing. The set and performance of sustainable equilibria depends crucially on agents' patience (Coate and Ravallion, 1993, Fafchamps, 1998). Fafchamps (1998) generalizes the two person model of Coate and Ravallion (1993) and shows that social or moral sanctions and community pressure against deviators can enlarge the set of sustainable equilibria. Fafchamps (1998) shows that when wealth heterogeneity is present, some quasi credit arrangement where loans and repayments are contingent to income shocks may be a mechanism able to implement informal insurance. Murgai, Winters, Sadoulet, and de Janvry (2002) point out that limits to informal insurance may come from an "association cost" and an "extraction cost". However, these exogenously given costs do not allow to understand the structural relationship between risk aversion, group size, heterogeneity of preferences, individual strategies and the degree of risk sharing achieved. As demonstrated also by Genicot and Ray (2002), the formation of coalitions within an informal risk sharing group may threaten the stability of such risk sharing groups, leading to a limited size of informal insurance groups.

Starting with the idea that the limits to the extent of informal risk sharing may be due to limited commitment problems, we want to explain the determinants of full risk sharing and test some theoretical predictions. As the value of perfect risk sharing determines the likelihood that commitment problems may alter risk sharing within a community, we study the theoretical effects of preferences heterogeneity on the value of perfect risk sharing within a community. We also look at the effect of the size of the risk sharing group and the degree of cross-sectional correlation of income shocks. Then, we show why in a limited commitment environment, the effect of the size of the risk sharing group may not be the same according to the possibility of households to commit to some risk sharing mechanisms and deviate individually or collectively. We derive several theoretical relationships that are supposed to affect the benefits of full risk sharing and thus the likelihood to deviate from such a risk sharing arrangement within a community.

Then, using some panel data form rural Pakistan, we try to test some testable implications on the consumption smoothing by households. We first present how one can allow heterogeneity of preferences in particular in risk aversion when testing full insurance on consumption data. Our empirical tests show that full insurance is rejected but we are then able to delimit some sets of villages where full insurance is rejected and other where it is not. Assuming that different degrees of risk sharing are reached by these heterogeneous communities, we study some characteristics of these villages and show some interesting correlations between them and the rejection of full insurance. Moreover, as our method allows to identify some heterogeneity in risk preferences, we study in particular the correlation between the village level of risk aversion and risk sharing. Our empirical results show that the more incomes are correlated across households within the village the more likely risk sharing is rejected and the higher the risk aversion level of the village the less consumption is insured against idiosyncratic shocks.

Section 2 presents some theoretical model that allows to derive some testable predictions on risk sharing.

Section 3 presents the econometric method, estimation and results.

2 Heterogeneity of Preferences, Limited Commitment and Coalitions in Informal Insurance

Intuitively, mutual insurance is better as the size of the risk pooling group increases because aggregate income becomes less and less risky. Then, why risk sharing groups would not become larger and tend to pool risk of all agents in the economy? Several reasons have been advanced. Fafchamps (1998) tells that information acquisition in larger and larger groups becomes costly and that this “transaction cost” could limit the group size. Fafchamps (1992) also says that the formation of a subcoalition can threaten the implementability of the allocation. Genicot and Ray (2002) show this phenomenon in a model with endogenous risk sharing groups. Coate and Ravallion (1993) limit their analysis to two agents and do not meet this problem of sub-coalition formation since the only feasible sub-coalition is then autarchy. Fafchamps (1998) and most other papers on informal risk sharing adopting the same kind of model with limited commitment use limited threatening strategies and avoid the problem of the size of the risk sharing group by considering that each agent’s strategy is to cooperate unless one deviates in which case all agents of the insurance group revert to autarchy. Murgai, Winters, Sadoulet, and de Janvry (2002) analyze the optimal size of the informal risk sharing group as well as the optimal extent of risk sharing by modelling an exogenous cost function (increasing in the share of exogenous income that must be shared and the size of the group) able to embody what they name as the association and extraction costs of informal insurance. The idea being that the association cost is due to the cost of sharing information on incomes of each member of the group which is assumed increasing with the size of the group. The extraction cost corresponding to the cost of enforcing a given extent of risk sharing measured by the parameter α determining the part of the "excess" income which must be shared with other members. These two ideas seem relevant but one would like to be able to explain them endogenously. In this paper, we show why informal risk sharing groups cannot be infinitely large. Genicot and Ray (2002) model a similar problem and show why coalitions limit the size of the informal risk sharing groups.

2.1 Complete Markets Hypothesis

We first look at the case where markets are complete and full insurance is obtained. In this case, denoting $u_t^{i\prime}$ the marginal utility of consumption for i at time t, μ_t is the Lagrange multiplier associated to the aggregate resource constraint, these first order conditions imply that for any agent i :

$$\forall i,\ \forall t, \qquad \frac{u_t^{i\prime}\left(c_{t+1}^i\right)}{u_t^{i\prime}\left(c_t^i\right)} = \frac{\mu_{t+1}}{\mu_t} \tag{1}$$

Thus, only aggregate risk should matter and consumption is insured against idiosyncratic risk. Then the Borch rule of risk sharing implies that in the particular case of utility functions with Constant Absolute Risk Aversion ($u^i\left(c_t^i\right) = -(1/\sigma_i)\exp\left(-\sigma_i c_t^i\right)$, where σ_i is the absolute risk aversion parameter), and with λ^i the Pareto weight of agent i in the social planner's objective, we have

$$c_t^k = \varphi_k + \frac{1/\sigma_k}{\sum_{i=1}^N 1/\sigma_i}\left(\sum\nolimits_{i=1}^N c_t^i\right) \tag{2}$$

where $\varphi_k = \frac{\ln\lambda^k}{\sigma_k} - \frac{\sum_{i=1}^N \frac{1}{\sigma_i}\ln\lambda^i}{\sigma_k\sum_{i=1}^N\frac{1}{\sigma_i}}$.

This sharing rule shows that agents having the same preferences and the same weight in the planner's objective will obtain an equal share of aggregate resources. With heterogenous preferences, individual consumption variability is inversely proportional to its absolute risk aversion. Remark that if all the $\lambda's$ are equal then $\varphi_k = 0$ and consumption is simply a share of aggregate consumption.

This implies that, if aggregate resources are distributed normally, defining the average absolute risk tolerance $\frac{1}{\overline{\sigma}} = \frac{1}{N}\sum_{i=1}^N 1/\sigma_i$, the value of perfect risk sharing within a group of size N denoted $v_N^c\left(N, \frac{1}{\overline{\sigma}}, \frac{1}{\sigma_k}\right)$ for agent k of absolute risk tolerance $\frac{1}{\sigma_k}$ is

$$\begin{aligned} v_N^c\left(N, \frac{1}{\overline{\sigma}}, \frac{1}{\sigma_k}\right) &= \frac{1}{1-\beta}Eu^k\left(c_t^k\right) \\ &= \frac{1}{1-\beta}u^k\left(\varphi_k + \frac{\overline{\sigma}}{\sigma_k}E\left(\frac{1}{N}\sum\nolimits_{i=1}^N c_t^i\right) - \frac{\overline{\sigma}}{2}V\left(\frac{1}{N}\sum\nolimits_{i=1}^N c_t^i\right)\right) \\ &= -\frac{1}{1-\beta}\frac{1}{\sigma_k}\exp -\sigma_k\left(\varphi_k + \frac{\overline{\sigma}}{\sigma_k}\left[y - \frac{\sigma_k}{2}Vy\right]\right) \end{aligned}$$

where y denotes expected aggregate consumption per household ($y = E\frac{1}{N}\sum_{i=1}^N c_t^i$) and Vy denotes the variance of $\frac{1}{N}\sum_{i=1}^N c_t^i$.

Now, for simplicity, let's assume that the Pareto weights are equal. Then, the value of perfect risk sharing among a group of size N for an agent of risk aversion σ_k is

$$v_N^c\left(N,\frac{1}{\overline{\sigma}},\frac{1}{\sigma_k}\right)=-\frac{1}{1-\beta}\frac{1}{\sigma_k}\exp-\overline{\sigma}\left[y-\frac{\sigma_k}{2}Vy\right]$$

and implies that:

Proposition 1 $v_N^c\left(N,\frac{1}{\overline{\sigma}},\frac{1}{\sigma_k}\right)$ *is increasing concave in* N*, decreasing in* $\frac{1}{\sigma_k}$*. It is decreasing in* $\frac{1}{\overline{\sigma}}$ *if* $y-\frac{\sigma_k}{2}Vy>0$.

Proof. As Vy is decreases and is convex in N, it is easy to show that $v_N^c\left(N,\frac{1}{\overline{\sigma}},\frac{1}{\sigma_k}\right)$ is increasing concave in N. Moreover, it is increasing in $\overline{\sigma}$ if $y-\sigma_k\frac{Vy}{2}$ and decreasing in $\frac{1}{\sigma_k}$ because

$$\frac{\partial}{\partial\left(\frac{1}{\sigma_k}\right)}\left(1-\beta\right)v_N^c=-\exp-\left(\frac{1}{\overline{\sigma}}\left[y-\frac{\sigma_k}{2}Vy\right]\right)\left[1+\overline{\sigma}\sigma_k\frac{Vy}{2}\right]<0$$

■

This proposition shows that the gains from perfect risk sharing increase with the size of the group but at a decreasing rate. Also, it shows that the value of perfect risk sharing for agent k decreases with risk aversion of the agent k (keeping the average risk tolerance $\frac{1}{\overline{\sigma}}$ constant) and increases in the average risk tolerance of the risk sharing group $\frac{1}{\overline{\sigma}}$.

Heterogeneity of Preferences and Endogenous Size of Risk Sharing Group

We now consider the possibility that insurance groups form endogenously based on preferences. Let's consider that given, a distribution of preferences in the economy, risk sharing groups can then be constituted of different sizes and with different levels of risk aversion parameters.

Then, a condition for this endogenous formation of risk sharing groups to be in equilibrium is that any two risk sharing groups characterized by the size of the group (N) and the level of risk tolerance $\frac{1}{\overline{\sigma}}$ should provide the same expected utility. Thus, agent k gets the same expected utility in groups i and j, if

$$v_N^c\left(N_i,\frac{1}{\overline{\sigma}_i},\frac{1}{\sigma_k}\right)=v_N^c\left(N_j,\frac{1}{\overline{\sigma}_j},\frac{1}{\sigma_k}\right)\qquad(3)$$

According to proposition 1, $v_N^c\left(N_i,\frac{1}{\overline{\sigma}_i},\frac{1}{\sigma_k}\right)$ is increasing in $\frac{1}{\overline{\sigma}_i}$ and N_i. Thus (3) implies that given $\frac{1}{\sigma_k}$, the size of the risk sharing group N_i will be decreasing with the risk tolerance level $\frac{1}{\overline{\sigma}_i}$. Therefore, if informal risk sharing groups actually form upon risk aversion, the value of perfect risk sharing for σ_k will be $v_N^c\left(N\left(\frac{1}{\overline{\sigma}_{i(k)}}\right), \frac{1}{\overline{\sigma}_{i(k)}}, \frac{1}{\sigma_k}\right)$ if the average risk tolerance of the risk sharing group of k is $\overline{\sigma}_{i(k)}$.

2.2 Limited Commitment

Now, let's consider an environment with limited commitment implying that any risk sharing agreement must be self enforcing within a set of players. Ligon, Thomas and Worrall (2002) estimate the benchmark structural model where individual deviations may limit risk sharing. Theoretically, Fafchamps (1998) or Coate and Ravallion (1993) use the result of Abreu (1988) that any sub-game perfect equilibrium for infinitely repeated game with discounting is a sub-game perfect equilibrium of the strategy giving the worst utility to agents who deviate. However, this threat may not be credible because several agents deviating simultaneously can form another group providing them a better utility than that of autarchy. Assume that we have N agents in a simple closed exchange economy. Individual income are random and present some idiosyncratic risk. Assume that they are independent and identically distributed across periods, identically distributed across agents either independently or with some degree of correlation $\rho < 1$. In this simple framework, even without commitment of agents not to renege ex post (after the realization of shocks), the cooperative solution can be a sub-game perfect equilibrium of the infinitely repeated game provided that some self sustainability constraints be satisfied. This sustainability constraint tells that the short run gain of any deviation must not exceed the long term gain from cooperation. For this, we use Abreu's result (Abreu, 1988) to construct agents' strategies. The strategy of an agent belonging to the informal insurance group, is such that he cooperates until someone deviates in which case he also deviates to autarchy where he gets his short term deviation pay-off plus the discounted utility of autarchy. Let's assume that we want to implement the full risk sharing allocation corresponding to the case where agents enjoy the same Pareto weights. In this case, they should divide equally the aggregate endowment among them. Let y_i be the realization at time t of the income stream of agent i. Therefore, the self sustainability constraint for each agent $i = 1, .., N$ is

$$u(y_i) + \beta v_a < u(\overline{y_N}) + \beta v_N^c \qquad (4)$$

where $\overline{y_N} = \frac{1}{N}\sum_{i=1}^{N} y_i$, $v_a = E\left[\sum_{\tau=0}^{\infty} \beta^\tau u\left(y_{i\tau}\right)\right]$ is the expected discounted payoff of autarchy and $v_N^c = E\left[\sum_{\tau=0}^{\infty} \beta^\tau u\left(\overline{y}_{N\tau}\right)\right]$ is the expected discounted payoff of cooperation in an informal insurance group of size N. The results of Kimball (1988), Coate and Ravallion (1993) follow. The feasibility of the informal insurance arrangement depends on agents patience (β), on their preference with respect to risk and on income distributions that all determine v_a and v_N^c.

For agents who have to transfer some part of their wealth to less endowed agents, (4) shows that the gain from deviation to autarchy never exceeds the benefit from cooperation if the utility difference between cooperation and autarchy is sufficiently large. Then, the cooperative equilibrium is implementable (Coate and Ravallion, 1993).

Intuitively, the informal insurance group should be as large as possible since a larger group allowing to mutually insure better against idiosyncratic risk of individual income. Actually, with an increasing concave utility function $u(.)$, $v_N^c = E\left[\sum_{\tau=0}^{\infty} \beta^\tau u\left(\overline{y_{N\tau}}\right)\right]$ is an increasing function of the size of the group N thanks to risk pooling. Then, we can prove the following proposition:

Proposition 2 *The welfare gain form perfect risk sharing $v_N^c - v_a$ increases with the size of the group N.*

Proof. See appendix A.1. ■

Thus, if the informal insurance group is sufficiently large so that risk pooling provides a sufficiently large utility gain from cooperation over autarchy, then the informal insurance is self enforceable. However, though the Pareto optimal full risk sharing allocation may be implementable, it has not necessarily the "core property". Actually, it may occur that a coalition of k agents ($1 < k < N$) may improve their utility by leaving the group and forming another smaller coalition. In a different model, Genicot and Ray (2003) introduce a concept of stability of groups and show then that the size of stable informal risk sharing groups is bounded. The difficulty is to define the structure of the game that would represent the intuition that threats of coalition formation should be taken into account. However, one can simply define some coalition-proofness conditions that would be required for any informal risk sharing group to be sustainable against deviations of coalitions.

Actually, risk sharing among N agents provides an instantaneous expected utility of $Eu\left(\overline{y_N}\right)$. The expected discounted pay-off of cooperation among k agents is $v_k^c = E\left[\sum_{\tau=0}^{\infty}\beta^\tau u\left(\overline{y_k}\right)\right]$ (by convention $v_1^c = v_a$ which is the expected discounted utility of autarchy). Thus, one can say that an informal risk sharing group of size N will be sustainable if all deviations of coalitions of subsets of these N agents cannot obtain a better utility by deviating jointly where in case of deviations they share income among the members of the coalitions and obtain an expected utility in future periods equal to the value of cooperating among them. This means that the following conditions must be satisfied: $\forall k < N$, $\forall \{y_i\}_{i=1,.,N}$:

$$u\left(\overline{y}_k\right) + \beta v_k^c \leq u\left(\overline{y}_N\right) + \beta v_N^c$$

It implies that we need that $\forall k < N$,

$$\max_{\forall \{y_i\}_{i=1,.,N}} \left\{u\left(\overline{y}_k\right) - u\left(\overline{y}_N\right)\right\} \leq \beta\left(v_N^c - v_k^c\right)$$

If income has a bounded support $[\underline{y}, \overline{y}]$ then[1] the required condition is that $\forall k < N$

$$u\left(\overline{y}\right) - u\left(\frac{k}{N}\overline{y} + \frac{N-k}{N}\underline{y}\right) \leq \beta\left(v_N^c - v_k^c\right) \tag{5}$$

For comparison purpose, let's consider the case where only deviations to autarchy are feasible. Then the condition is that

$$u\left(\overline{y}\right) - u\left(\underline{y} + \frac{\overline{y} - \underline{y}}{N}\right) \leq \beta\left(v_N^c - v_1^c\right)$$

Thus, it is always satisfied for N large enough since $u\left(\overline{y}\right) - u\left(\underline{y} + \frac{\overline{y}-\underline{y}}{N}\right) \leq u\left(\overline{y}\right) - u\left(\underline{y}\right)$ and $v_N^c - v_1^c$ is increasing in N (as soon $\lim_{N\to\infty}\beta\left(v_N^c - v_1^c\right) > u\left(\overline{y}\right) - u(\underline{y})$).

However, the conditions (5) are not always satisfied for N large enough. Actually, this would imply that

$$u\left(\overline{y}\right) - u\left(\frac{\overline{y} + \underline{y}}{2}\right) \leq \beta\left(v_N^c - v_{N/2}^c\right)$$

[1] Actually

$$\max_{\overline{y}_k, \overline{y}_N}\left(u\left(\overline{y}_k\right) - u\left(\overline{y}_N\right)\right) = \max_{\overline{y}_k, \overline{y}_{N-k}}\left(u\left(\overline{y}_k\right) - u\left(\frac{k}{N}\overline{y}_k + \frac{N-k}{N}\overline{y}_{N-k}\right)\right)$$
$$= \max_{\overline{y}_k}\left(u\left(\overline{y}_k\right) - u\left(\frac{k}{N}\overline{y}_k + \frac{N-k}{N}\underline{y}\right)\right) = u\left(\overline{y}\right) - u\left(\frac{k}{N}\overline{y} + \frac{N-k}{N}\underline{y}\right)$$

because

$$\frac{\partial}{\partial y}\left[u\left(y\right) - u\left(\frac{k}{N}y + \frac{N-k}{N}\underline{y}\right)\right] = \left[u'\left(y\right) - \frac{k}{N}u'\left(\frac{k}{N}y + \frac{N-k}{N}\underline{y}\right)\right] > 0$$

which is not always true for N large enough since $v_N^c - v_{N/2}^c$ decreases and goes to zero with N (for example if utility is quadratic, $u(x) = x - \frac{\sigma}{2}x^2$, in which case $v_N^c - v_{N/2}^c = \frac{1}{1-\beta}\frac{1}{N}\frac{\sigma}{2}(1-\rho)\,\omega^2$).

We thus obtain the following general result similar to that of Genicot and Ray (2003):

Proposition 3 *Large enough informal risk sharing groups are always sustainable against individual deviations to autarchy but not to deviations by coalitions.*

However, one could also define a stronger concept and require also that deviations to form a subcoalition of size k must not be dominated by any sub-coalition, that is $\forall\ k < k' \leq N$, $\forall \{y_i\}_{i=1,.,N}$:

$$u(\overline{y}_k) + \beta v_k^c \leq u(\overline{y}_{k'}) + \beta v_{k'}^c \tag{6}$$

With lemma 7 in appendix A.1, we know that v_k^c is increasing in k, so $v_k^c < v_{k'}^c$ if $k < k'$. However, it may be possible that $\overline{y}_k > \overline{y}_{k'}$ implying that the coalition proofness constraints may not always be respected. It will depend on the income distributions determining $v_{k'}^c - v_k^c$, and on the support of incomes determining the maximal feasible difference $u(\overline{y}_k) - u(\overline{y}_{k'})$ between the average income of a group of size k and the average income of a larger group.

The usual condition (Fafchamps, 1998, Coate and Ravallion, 1993) for cooperation to be a subgame perfect equilibrium of the infinitely repeated game allowing only individual deviations is that $\forall \{y_i\}_{i=1,.,N}$:

$$u(y_i) + \beta v_1^c \leq u(\overline{y}_N) + \beta v_N^c \tag{7}$$

Coalition proofness changes the set of risk sharing equilibria sustainable to deviations to autarchy (Fafchamps 1998, Coate and Ravallion, 1993) since it may happen that individual reversion to autarchy is not worth compared to full risk sharing among the N agents while the joint deviation of a coalition is. This happens when $\overline{y}_k > u^{-1}\left[u(\overline{y}_N) + \beta(v_N^c - v_k^c)\right]$ while $y_i \leq u^{-1}\left[u(\overline{y}_N) + \beta(v_N^c - v_a)\right]$ (which is possible since $v_k^c \geq v_a = v_1^c$).

We now consider a particular case of this model by specifying utility functions in order to derive some testable predictions on informal insurance.

2.3 Coalitions versus Individual Deviations in a Simplified Model of Informal Risk Sharing

We now make some assumptions that simplify analytically the problem in order to derive some testable predictions on a stylized model. Assume that we can write the expected utility of consumption as a function of its mean and variance. This means that we neglect higher order moments of the consumption distribution. However, if we assume that incomes are normally distributed and utility has a constant absolute risk aversion or if utility is quadratic, then expected utility depends only on the mean and variance of consumption.

For simplicity, let's assume the following:

Assumption 1 The utility function is quadratic: $u(z) = z - \frac{\sigma}{2}z^2$ $(\sigma > 0)$.

Assumption 2 Incomes have mean y and support[2] equal to $[\underline{y}, \overline{y}]$ and variance-covariance matrix[3] $\Omega = (1-\rho)\,\omega^2 I + \rho\omega^2 J$ (in the special case of independence, $\rho = 0$ and $\Omega = \omega^2 I_N$).

Assumption 1 implies that the expected utility is a mean variance criterion of the random consumption level. ρ is the correlation between income of any two persons and ω^2 their variance. For notational ease, we note by $\sigma(z) = \frac{-u''(z)}{u'(z)}$.

Lemma 4 *With assumptions 1 and 2, the difference in the intertemporal utilities of cooperation between N and k participants is*

$$v_N^c - v_k^c = \frac{1}{1-\beta}\frac{N-k}{Nk}\frac{\sigma}{2}(1-\rho)\,\omega^2 \tag{8}$$

It is positive, increasing and concave in N, decreasing and convex in k, increasing in β, σ and ω^2, and decreasing in ρ.

Proof. For $k = 1,.,N$: $v_k^c = E\sum_{t=0}^{\infty}\beta^t u(\overline{y_{kt}}) = \frac{1}{1-\beta}Eu(\overline{y_k}) = \frac{1}{1-\beta}\left[E\overline{y_k} - \frac{\sigma}{2}E(\overline{y_k}^2)\right]$. So $v_k^c = \frac{1}{1-\beta}\left[E\overline{y_k} - \frac{\sigma}{2}(V(\overline{y_k}) + (E\overline{y_k})^2)\right]$. With $Ey_i = y$ and $V(y_i) = \omega^2$, $V(\overline{y_k}) = \omega^2\left[\frac{1-\rho}{k} + \rho\right]$ and $E\overline{y_k} = y$, so $v_N^c - v_k^c = \frac{1}{1-\beta}\frac{N-k}{Nk}\frac{\sigma}{2}\omega^2(1-\rho)$. ■

[2] We assume that γ or $\overline{y}$ are small enough such that $\overline{y} < 1/\gamma$.

[3] I is the identity matrix of size N and J is a square matrix of size N with all elements equal to one.

The preceding lemma shows again that the value of cooperation within a larger group provides a higher expected utility. It also shows that this difference is increasing with the degree of patience of agents. The difference in the expected value of cooperation in a larger group is increasing but the marginal gain from adding one more agent in the group is decreasing. Of course, this difference is increasing with risk aversion (σ) and with the variability of income (ω^2) but decreasing with the degree of correlation ρ between incomes which is intuitive since the expected gain from pooling resources is smaller when income shocks are more correlated.

For notational convenience, we define $\delta(k, N)$ the ratio of the maximal possible k-deviation gain over the discounted expected gain of future risk sharing among N persons rather than k (omitting other parameters in the arguments):

$$\delta(k, N) = \frac{\max_{\overline{y}_k, \overline{y}_N} \left(u\left(\overline{y}_k\right) - u\left(\overline{y}_N\right)\right)}{\beta\left(v_N^c - v_k^c\right)}$$

Of course, the informal insurance group is weakly coalition proof if and only if $\forall k < N : \delta(k, N) \leq 1$. Within the same framework, the corresponding condition for sustainability of informal insurance with respect to deviations to autarchy is $\delta(1, N) \leq 1$. Then, denoting N_a^* the maximum size of the informal insurance group sustainable against individual deviations and N^* the maximum size of the coalition-proof informal insurance group, we can prove that:

Proposition 5 *With assumptions 1 and 2, N_a^* and N^* are increasing in β, ω^2, σ, and decreasing in ρ. N^* is smaller than N_a^* and is finite ($N^* < +\infty$). Moreover there exists $\beta^* < 1$ such that for $\beta > \beta^*$, $N_a^* = +\infty$.*

Proof. See appendix A.2. ■

The fact that for $\beta > \beta^*$, $N_a^* = +\infty$ means that for sufficiently patient agents, the informal insurance group is always sustainable against deviations to autarchy whatever the size of the group. Finally, one can look at the welfare gains over autarchy or over coalitions of risk sharing among N agents. Using (8), we can contrast the differences between the value of sharing risk among N agents and the value of autarchy $v_N^c - v_1^c$ and the difference between the value of sharing risk among N agents and the value of sharing risk within the coalition providing the highest welfare $\min_{k \in \{1,..,N-1\}} (v_N^c - v_k^c)$.

Proposition 6 *The differences between risk sharing in a group of size N and autarchy or risk sharing in the best coalition of size* $k \in \{1, .., N-1\}$ *satisfy the following inequalities*

$$\frac{\partial}{\partial N}\left(\min_{k\in\{1,..,N-1\}}\left(v_N^c - v_k^c\right)\right) < 0 < \frac{\partial}{\partial N}\left(v_N^c - v_1^c\right) \tag{9}$$

and

$$\frac{\partial}{\partial N \partial \rho}\left(v_N^c - v_1^c\right) < 0 < \frac{\partial}{\partial N \partial \rho}\left(\min_{k\in\{1,..,N-1\}}\left(v_N^c - v_k^c\right)\right) \tag{10}$$

and

$$\frac{\partial}{\partial N \partial \sigma}\left(v_N^c - v_1^c\right) > 0 > \frac{\partial}{\partial N \partial \sigma}\left(\min_{k\in\{1,..,N-1\}}\left(v_N^c - v_k^c\right)\right) \tag{11}$$

Proof. Straightforward derivation using (8) and

$$\min_{k\in\{1,..,N-1\}}\left(v_N^c - v_k^c\right) = v_N^c - v_{N-1}^c = \frac{1}{1-\beta}\frac{1}{N\left(N-1\right)}\frac{\sigma}{2}\left(1-\rho\right)\omega^2$$

■

Proposition 6 thus shows that the larger the size of the risk sharing group, the larger the welfare gains of perfect risk sharing against autarchy but the smaller against coalitions. Also, the welfare gains over autarchy of increasing the size of the group are lower with more correlated incomes (higher ρ) but the gains over coalitions decrease at a lower rate with the size of the group for more correlated incomes. Finally, with higher risk aversion (σ) the gains over autarchy increase more with the size of the group and the gains over coalitions decrease more. These results imply some testable implications. Actually, if only individual deviations threaten the sustainability of informal insurance groups but not coalitions, then the larger the group size the larger the gains from cooperation. Moreover, testing whether coalition or only individual deviations restrict risk sharing in a limited commitment environment will be provided by evidence on whether the likelihood to accept perfect risk sharing increases or decreases with N for more risk averse and less correlated incomes.

3 Econometric Estimation and Tests

In order to test the predictions about the sources of the limits to perfect risk sharing in a limited commitment environment, we first present how one can account for heterogeneity in risk aversion in the tests of full insurance within each village. Then we present some stylized facts and the empirical tests on data from rural Pakistan.

3.1 Testing Full Insurance with Heterogeneous Preferences

Most of the tests of the complete markets hypothesis assume homogeneity of preferences with respect to risk. Some kind of heterogeneity is sometimes taken into account by parameterizing the marginal utility of consumption (Mace, 1991, Cochrane, 1991) but never in the degree of risk aversion. Only Townsend (1994) provides a test of full insurance with heterogeneity of risk aversion using household level time series, but the power of the test is then very weak. With CARA preferences, full insurance predicts that household consumption must be a linear function of aggregate consumption (Wilson, 1968) with a slope equal to the ratio of household to community average absolute risk tolerance (the inverse of absolute risk aversion). Townsend (1994) regresses household by household consumption on aggregate consumption at the village level including successively proxy variables for household idiosyncratic shocks testing if the coefficient of the idiosyncratic variable is equal to zero and if that of the aggregate consumption coefficient is equal to one. But the power of these tests is very weak given the short time dimension of panel data on consumption (10 periods in Townsend, 1994). Moreover, in the case where households would have a constant absolute risk aversion equal to σ_i for household i, full risk sharing (complete markets) predicts that the coefficient of aggregate consumption β_i must be equal to the ratio of household to average absolute risk tolerance i.e. $\beta_i = \frac{1/\sigma_i}{\frac{1}{N}\sum_{j=1}^{N}\frac{1}{\sigma_j}}$ where N is the size of the risk sharing group (for example the village). Consequently, the correct way to test the complete markets hypothesis with these time series estimates is not to test $\beta_i = 1$ (which amounts to assume homogeneity) but rather $\frac{1}{N}\sum_{i=1}^{N}\beta_i = 1$ i.e. that the average of estimated coefficients should be equal to one. However, this test remains weak and measurement errors on consumption will turn it even more unreliable (Ravallion and Chaudhuri, 1997).

Another method of testing the full insurance property used by Townsend (1994) or Mace (1991) consists in imposing homogeneity of risk aversion among agents. Then, thanks to panel data, the test consists in regressing the first difference of household consumption (or its logarithm) on the income change and to test that the income shock does not affect consumption change. This method is valid under the assumption that all agents have homogeneous risk aversion. However, the method consisting in using dummy variables to purge the aggregate shock effect on consumption change (Deaton, 1997) instead of subtracting the average consumption change to the individual consumption change (Grimard, 1997, Jalan and Ravallion, 1999) allows to avoid the attenuation bias of the income coefficient under the alternative hypothesis where this coefficient would be strictly positive (Ravallion and Chaudhuri, 1997). Actually, under the null hypothesis, both methods lead to consistent estimators but under the alternative the method using differences to aggregate consumption is biased. The complete markets hypothesis predicts that the marginal utility of consumption increases at the same rate for each agent (Altug and Miller, 1990). With isoelastic utility functions, even if preferences are heterogeneous and unobserved, it remains that an increasing function of the growth rate of marginal utility depends only on aggregate resources and not on idiosyncratic shocks. If idiosyncratic shocks are assumed independent of household preferences, then they must be cross sectionally independent of the growth rate of consumption (Cochrane, 1991). Jacoby and Skoufias (1998) use this method which depends crucially on the assumption of independence of preferences and idiosyncratic shocks (which can be correlated if both are correlated to demographic characteristics for example).

Assume that the instantaneous utility of consumption c for household i at time t is of the isoelastic following form[4]

$$\beta^t u_{it}(c) = \exp\left(\alpha\left(\widetilde{z}_{it}\right)\right) \frac{c^{1-\sigma(z_{it})}}{1-\sigma\left(z_{it}\right)} \tag{12}$$

where vectors z_{it}, $\widetilde{z}_{it}$ are characteristics of household i at time t and β the discount factor (vectors z_{it}, $\widetilde{z}_{it}$ can consist in the same or in different variables, their notations are distinguished in the econometric model because they will not be treated in the same manner by the instrumentation method even if they can finally be the same set of variables in the empirical application). We thus assume that households have a constant relative risk aversion (in consumption level for a given household) equal to $\sigma\left(z_{it}\right)$ which depends on some characteristics z_{it}. Similarly, Blundell, Browning and Meghir (1994) and Hayashi, Altonji and Kotlikoff (1996) parameterized multiplicative factors of marginal utility of consumption with observable

[4] The most prevalent parametric forms used are the exponential (Constant Absolute Risk Aversion) and isoelastic (Constant Relative Risk Aversion) forms. In the case of Mace (1991), it seems that the opposite conclusions given by CRRA or CARA functions came from measurement error problems (Nelson, 1994). Ogaki and Zhang, 2001, use utility functions in the class of HARA (Hyperbolic Absolute Risk Aversion). However, our strategy is rather to allow for heterogeneity of risk aversion in the class of CRRA functions than specifying a unique homogeneous HARA function for each household.

characteristics ($\alpha(\widetilde{z}_{it})$) but were assuming that risk aversion was homogeneous across households or individuals. Hence, we have parameterized the marginal utility of consumption with $\alpha(\widetilde{z}_{it})$ and the relative risk aversion by $\sigma(z_{it})$.

The first order condition verified by the marginal rate of substitution of consumption between periods t and $t+1$ is then:

$$\frac{u'_{it+1}(c_{it+1})}{u'_{it}(c_{it})} = \varepsilon_{it+1} \tag{13}$$

where ε_{it+1} is a random variable whose distribution depends on the hypothesis on markets completeness.

Using (12), this first order condition can be written

$$\alpha(\widetilde{z}_{it+1}) - \alpha(\widetilde{z}_{it}) - \sigma(z_{it+1}) \ln c_{it+1} + \sigma(z_{it}) \ln c_{it} = \ln \varepsilon_{it+1} \tag{14}$$

The function $\sigma(.)$ can be identified only up to a multiplicative constant. Assuming that the functions $\alpha(.)$ and $\sigma(.)$ are linear, we normalize $\sigma(.)$ by writing

$$\sigma(z_{it}) = 1 + z_{it}\sigma \tag{15}$$

The relative risk aversion of household i at t is assumed to be a function of observable characteristics z_{it}. Homogeneity of relative risk aversion among agents is obtained when $\sigma = 0$. The function $\alpha(.)$ allows to introduce multiplicative shocks to marginal utility of consumption eventually depending on observable characteristics $\widetilde{z}_{it}$. Taking a linear additive form between an unobservable shock η_{it} and the factor $\widetilde{z}_{it}\alpha$ function of observable variables , we write

$$\alpha(\widetilde{z}_{it}) = \widetilde{z}_{it}\alpha + \eta_{it} \tag{16}$$

The term η_{it} captures unobserved specific effect multiplicative to marginal utility of consumption (for example like individual variations in the discount factor).

Then the first order condition becomes

$$\Delta \ln c_{it+1} = [-z_{it+1} \ln c_{it+1} + z_{it} \ln c_{it}]\,\sigma + \Delta\widetilde{z}_{it+1}\alpha + \Delta\eta_{it+1} - \ln \varepsilon_{it+1} \tag{17}$$

or equivalently

$$\Delta \ln c_{it+1} = [-z_{it+1}\Delta \ln c_{it+1} - \ln c_{it}\Delta z_{it+1}]\,\sigma + \Delta\widetilde{z}_{it+1}\alpha + \Delta\eta_{it+1} - \ln \varepsilon_{it+1} \tag{18}$$

where Δ is the first difference operator defined by $\Delta X_{t+1} = X_{t+1} - X_t$.

Assume now that consumption is measured with error independently distributed across households and periods. We observe $\widetilde{c}_{it}$ instead of true consumption c_{it}:

$$\ln \widetilde{c}_{it} = \ln c_{it} + u_{it} \tag{19}$$

Measuring consumption is a difficult task in any household survey and measurement errors are almost always present. Taking into account explicitly measurement error, the first order condition is

$$\Delta \ln \widetilde{c}_{it+1} = \left[-z_{it+1}\Delta \ln \widetilde{c}_{it+1} - \ln \widetilde{c}_{it}\Delta z_{it+1}\right]\sigma + \Delta \widetilde{z}_{it+1}\alpha + v_{it+1} \tag{20}$$

with[5] $v_{it+1} = \Delta\eta_{it+1} - \ln \varepsilon_{it+1} + (1 + z_{it+1}\sigma)\,\Delta u_{it+1} + u_{it}\Delta z_{it+1}\sigma$.

Now, we give precisely the properties of random terms ε_{it+1} according to the hypothesis made on markets completeness:

Full insurance: under the complete markets hypothesis, the random terms ε_{it+1} are aggregate temporal shocks: $\varepsilon_{it} = \varepsilon_t$.

Full insurance within the village: under the complete markets hypothesis in each village v, the random terms ε_{it+1} are village-level aggregate temporal shocks: $\varepsilon_{it} = \varepsilon_t^v$.

We make the following assumption concerning the disturbance terms:

Assumption a: The measurement errors on consumption u_{it} are independent and identically distributed across households and periods.

Assumption b: Conditional on observable household characteristics z_{it}, the unobservable preference shocks η_{it} are martingales independent across households and independent of measurement errors[6].

Thus, we can test full insurance taking into account the heterogeneity of preferences but also identify risk aversion up to a multiplicative factor. The usual tests of complete markets or full insurance consist in "directional tests" against precise alternatives. They consist in testing the null hypothesis against the alternative that the random terms ε_{it+1} depend on a household idiosyncratic shock. For example,

[5] $(1 + \theta z_{it+1})\,\Delta u_{it+1} + \theta u_{it}\Delta z_{it+1} = (1 + \theta z_{it})\,\Delta u_{it+1} + \theta u_{it+1}\Delta z_{it+1}$

[6] $\Delta\eta_{it+1}$ is a martingale difference implying that $\Delta\eta_{it+1}$ is independent of $\Delta\eta_{it}$.

if a negative income shock reduces household consumption during some period, markets are incomplete because otherwise shocks should be fully insured. But, as in Dubois (2000), an overidentifying restrictions test of the model (20) allows to perform a "non directional" test of the null hypothesis of complete markets. This test is non-directional in the sense that it does not test the model against some known alternative but simply tests the internal consistency of the estimated model. This test has the advantage that it needs not a known testable alternative that is data like idiosyncratic shocks. However, a directional test is likely to be more powerful. We therefore use also directional tests. In the case of the within-village full insurance, if random terms $\ln \varepsilon_{it+1}$ contain a household specific idiosyncratic innovation then the within-village complete markets hypothesis is rejected. Consequently, with a variable ω_{it+1} correlated with the innovation ξ_{it+1} $(= \delta [\omega_{it+1} - E_t \omega_{it+1}])$, we then only need to test that $\delta = 0$ in the estimation of the following equation:

$$\Delta \ln \widetilde{c}_{it+1} = [-z_{it+1} \Delta \ln \widetilde{c}_{it+1} - \ln \widetilde{c}_{it} \Delta z_{it+1}] \sigma + \Delta \widetilde{z}_{it+1} \alpha + \delta \omega_{it+1} + \widetilde{v}_{it+1} \tag{21}$$

with $\widetilde{v}_{it+1} = v_{it+1} - \delta \omega_{it+1} = \Delta \eta_{it+1} + (1 + z_{it+1} \sigma) \Delta u_{it+1} + u_{it} \Delta z_{it+1} \sigma - \ln f(X_{it}) + \xi_{it+1}$ and $\xi_{it+1} = \delta [\omega_{it+1} - E_t \omega_{it+1}]$.

Instrumental variables estimation:

To estimate equation (20) under the null hypothesis, we include some village-time dummy variables, and use the two stage least squares instrumental variables method because the right hand side variables $[z_{it+1} \Delta \ln \widetilde{c}_{it+1} + \Delta z_{it+1} \ln \widetilde{c}_{it}]$ are endogenous. Current and lagged exogenous variables (z_{it+1}, z_{it}), and any variable uncorrelated with preference shocks or measurement errors at time t and $t+1$ are used as instrumental variables. However, the use of a large number of instrumental variables frequently leads to a weak instruments problem and to biased estimators (Bound, Jaeger and Baker, 1995). To avoid the weak instruments problem which can sensibly affect the asymptotic size of the overidentifying restrictions tests and bias the instrumental variables estimators in finite samples (Buse, 1992, Magdalinos, 1994, Bound, Jaeger and Baker, 1995, Staiger and Stock, 1997), we restrict our set of instrumental variables. Consequently, we compute which instruments should be the best correlated to endogenous variables. Appendix A.4 shows how we determine the set of instrumental variables that should have the strongest correlation with the endogenous variables under the null hypothesis. These instruments: $\Delta z_{it+1} \ln c_{it-1}$ and $z_{it} \Delta \widetilde{z}_{it} - z_{it+1} \Delta^2 \widetilde{z}_{it+1}$ (whose set is denoted [1] in Tables of results) and also $\Delta z_{it+1}\left(z_{it+1}+z_{it}-z_{it-1}\right)\ln c_{it-1}$ and $z_{it+1}^2\Delta^2\widetilde{z}_{it+1}-z_{it}^2\Delta\widetilde{z}_{it}$ (that then constitute the set of instrumental variables denoted [2]) should be valid under the null hypothesis. Thus, doing an overidentifying restrictions test, for example with the Sargan statistic, we get a test of the null hypothesis of full insurance. We report part of the first stage instrumental regressions in Appendix A.5.

The estimation of (20) under the null hypothesis of within village complete markets necessitates the inclusion of numerous dummy variables on the right hand side of the equation (village-time dummies for the within-village full insurance test) but their estimates will not be presented in Tables of results[7].

At last, we remark that when there are measurement errors on consumption, the residuals of equation (20) are autocorrelated because $cov(v_{it+1},v_{it})=-\left(1+z_{it+1}\sigma\right)\left(1+z_{it}\sigma\right)var(u_{it})$. It is necessary to take this autocorrelation into account in our estimation.

3.2 Data and Descriptive Statistics

The data come from a survey conducted by IFPRI (International Food Policy Research Institute) in Pakistan between 1986 and 1989 (see Alderman and Garcia, 1993). The survey consists of a stratified random sample interviewed 12 times beginning with 927 households from four districts of three regions (Attock and Faisalabad in Punjab, Badin in the Sind, and Dir in the North West Frontier Province). For each of the four districts, the villages were chosen randomly from an exhaustive list of villages classified in three sets according to their distances to two markets (*mandis*). In each village, households were randomly drawn from an exhaustive list. The attrition observed in the data (927 households at the beginning and only 887 at the end) seems to come from administrative and political problems rather than from a self selection of households (Alderman and Garcia, 1993). We consider this attrition phenomenon as exogenous. Although the sample is entirely rural, it is not completely agricultural, which has an influence on the distribution and fluctuations of incomes. However, of the 927 households chosen in the first period, only 22 never

[7] Moreover, by the Frisch-Waugh theorem, the regression (20) with dummy variables for each village and period is exactly equivalent to the regression done by replacing all variables by their image through the projection operator on the orthogonal space generated by the corresponding dummy variables (the dependent, explanatory and instrumental variables). The coefficients of all these dummy variables are very numerous (46 villages×12 periods resulting after first differences in 505 coefficients). We can then transform the model and estimate it by subtracting the period-village average which is equivalent to the use of the whole set of dummy variables.

had any agricultural income during the survey. The available data are very rich and contain information on household demographic characteristics, on incomes disaggregated in numerous sources, on individual labor supplies, on endowments and owned assets, on agrarian structure, on crops and productions. Some descriptive statistics appear in Table 1.

Income sources are wages, agricultural profits, rents from property rights, pensions, informal transfers (from relatives or others).

[TABLE 1 HERE]

The expenditures and incomes are in 1986 Rupees per week, areas are in acres[8]. Correlations between income sources for the total sample show that there is quite little covariation between these sources. Actually the correlation coefficient between agricultural profits and wage income is only -0.01. The correlation coefficient between agricultural profits and pensions and transfers received is 0.08 and it is 0.70 between agricultural profits and total income. This should allow income diversification, but all households do not hold this market portfolio. In particular, the average share of each income source in the total income shows for example that landless households have a much more important part of their income from wages. Landless households have on average 80% of their income from wages whereas it is only one third for landowners. In general, for these rural households, income variability is high because of the Monsoon, of weather variability generating periods of drought, and of relatively frequent flooding. Besides, the (pseudo) coefficients of variation of household income[9] are large, ranging from 0.31 to 2.76, with a household average of 0.86 (0.84 on average in Punjab and Sind and 0.90 in the North West Frontier Province). On the contrary, the coefficients of variation of household consumption are much lower, ranging from 0.009 to 1.98 with an average of 0.40. Only 46 households of 927 have a coefficient of variation of consumption higher than that of income (97 in the case of total non durable expenditures). Assuming that instantaneous utility is separable between durable and non durable goods, we can estimate the model using non durable

[8] Units: 1 Pakistan Rupee (1986) = US\$0.0062, 1 acre = 4046.86 m^2.

[9] The per period incomes are net of production input expenditures and then can sometimes be negative. The pseudo coefficient of variation of y_{it} for a household i is computed as $\frac{\left(T\sum_{t=1}^{T} y_{it}^2 - \left(\sum_{t=1}^{T} y_{it}\right)^2\right)^{1/2}}{\sum_{t=1}^{T} y_{it} - T \min_{i=1,..,T}(y_{it})}$.

expenditures as our consumption variable. In the literature on full insurance tests, food consumption is often used (Townsend, 1994, Mace, 1991, Cochrane, 1991). Hence, we perform our tests with both food and non durable expenditures.

At last, we have to take into account the seasonality of behavior. Paxson (1993) has shown the importance of seasonality in the case of Thailand data. The problem would be less stringent with annual data, but here the average gap between interviews is about four months. Seasonality is a priori an important phenomenon for these rural households for calendar reasons linked to agricultural activity and religion (Islam). The agricultural activity in Pakistan is markedly affected by the Monsoon, generating two plantation and harvest seasons (Kharif for the most humid and Rabi for the driest), which dates vary with region according to latitude. For the Punjab province, the planting period of the Rabi season is in November-December, and harvests are in March-April. The plantation period of the Kharif season is in May and July and harvests are in October and December. We have then to take into account these seasonal effects in the various specifications because they affect incomes but also mark the rural life with several celebrations (as the lights feast called *dipavali* at the end of October and many other ones) or with the seasonal fluctuations of frequent pathologies (viral diseases, malaria and leishmaniasis). In addition to this seasonal structure and by several celebrations from Hindus origin, seasons are affected by the religious Islamic calendar. Several reasons justify then the presence of seasonality in behavior and preferences of rural households from Pakistan. The total population of the 46 villages varies between 200 and 8000 inhabitants by village with an average of 1818 and a median of 1108. The average density of the population of these villages is high with 276 inhabitants per km^2 which is higher than the Pakistan average of 163 inhabitants by km^2 (World Bank, 1997). 61% of households of this sample own a plot of land. The average area owned is 9.42 acres or approximately 3.8 hectares but less than a half of these lands are irrigated.

3.3 Empirical Tests: Full Insurance and its Limits

We use the method presented before to test the full insurance property without being forced to do strong homogeneity assumptions on preferences. The empirical tests consist in estimating equations (20) and (21) with the instrumental variables method described before. The instrumental regressions are given in appendix A.5 with or without the inclusion of the income shock. The correlation between endogenous variables and the instrumental variables show that we can exclude weak instruments problems. Therefore, the test of overidentifying restrictions given by the Sargan statistic allows us to test the null hypothesis of full insurance since these instruments are theoretically valid under the null hypothesis. This non directional test of the null hypothesis is implemented first with the assumption of separability between consumption and leisure in the utility function and then with the non separable specification (22) allowing to take into account labor supply. When labor supply is used in the regressions, the twice lagged variables for male and female household labor supply are introduced among the instruments: l^m_{it-1}, l^f_{it-1}. So as to take into account measurement errors in income, we use the rental incomes as instruments for agricultural benefits. These instruments appear to be very informative because sufficiently correlated with agricultural profits (see instrumental regression in Table 6 of Appendix A.4), which enables to identify the parameter δ of agricultural profit with more precision (compared to OLS estimations). When income is not instrumented, the estimated parameter $\widehat{\delta}$ is much closer to zero and its standard error is two to four times larger.

For the exogenous characteristic variables of households z_{it+1} and $\widetilde{z}_{it+1}$, the estimates presented show the case where these variables are household size, number of children in household and irrigated owned land per household adult equivalent[10]. This specification results from a preliminary research that showed that other demographic characteristics or the composition of owned land do not bring additional information in the regressions.

Within-village Full Insurance

In Dubois (2000), we have shown that the complete markets hypothesis in the whole country is strongly rejected whatever the number of instruments used using the tests of overidentifying restrictions by the Sargan statistic. We thus test the within village complete markets hypothesis. It may happen that households manage to insure themselves against risks with borrowing, lending, solidarity networks, credit and other mechanisms within the village.

Even if very cautious in the choice of instrumental variables and if we have checked that they were sufficiently informative, we always tried to raise the arbitrary level of significance required in instrumental

[10] We use the definition of Townsend (1994) for the equivalence scales but the results change only very slightly when we use other equivalence scales or simply the household size.

regressions fo keep an instrument. The choice of instruments needs a particular attention to Fisher statistics in instrumental regressions (the instrumental regressions of column (5) of Table 2 are reported in A.4). The columns (1) and (5) of Table 2 show the estimation of the model under the null hypothesis as well as the overidentifying restrictions tests (Sargan statistic) that reject the within village complete markets hypothesis. However, the estimated parameters are much less precise in that case when instruments [1] only are used. In the consumption leisure non separable case (columns (2) and (6) of Table 2), the overidentifying restrictions test is not always rejected. This non directional test does not allow to reject the within village complete markets hypothesis. But, the directional tests reject it because agricultural income shocks have a significant effect on household consumption changes.

[TABLE 2 HERE]

Preferences

The estimated parameters σ show that household risk aversion increases with the number of children and decreases with owned irrigated land per adult equivalent. The number of children within the household increases risk aversion which can be interpreted by the fact that children are more sensitive to consumption variations. Households owning more land (per adult equivalent) are less risk averse which corresponds to the usual wealth interpretation that household risk aversion decreases as a function of owned assets[11].

In addition, the estimated parameters for seasonal dummies show that households are more risk averse during the Kharif harvest period i.e. after the Monsoon. This period is the fourth trimester of the year and is the period of the more important and risky harvest of the year. This season also corresponds to the period where numerous traditional feasts occur. It seems that this period is a crucial one during the year and has then an influence on household preferences turning them more risk averse[12].

The estimation of parameters α shows that the marginal utility of consumption increases with household size and with its wealth in terms of owned irrigated land per adult equivalent.

At last in the case of non separability between consumption and leisure, the labor supply parameters are

[11] This argument is often used to proxy risk aversion with wealth like in Ackerberg and Botticini (2002).

[12] For other periods, it seems that during the Monsoon and winter, households are a bit more risk averse than during the Rabi harvest, but the estimated coefficients are not significantly different.

quite imprecisely estimated. The results on other coefficients of interests are very slightly modified. It seems for instance that separability between consumption and leisure can be accepted for these rural households of Pakistan conditionally to the chosen specification taking into account heterogeneity in preferences.

The limits to risk sharing:

As full risk sharing may be obtained in some villages and not others, we test full risk sharing as in Table 2 but allowing the coefficient δ_v of the effect of the idiosyncratic shock to be specific to each village. We do so by interacting agricultural income shocks with village dummy variables. We also use interactions between rental incomes and village dummy variables as instruments. Thus equation (21) becomes

$$\Delta \ln \widetilde{c}_{it+1} = \left[-z_{it+1}\Delta \ln \widetilde{c}_{it+1} - \ln \widetilde{c}_{it}\Delta z_{it+1}\right]\sigma + \Delta \widetilde{z}_{it+1}\alpha + \delta_v \omega_{it+1} + \widetilde{v}_{it+1}$$

Overall, the estimation results look similar to those of Table 2 except that 46 coefficients δ_v are now estimated. We will also consider the case where δ_v depends also on the season and is denoted δ_{vt}. We do not report the full results but rather examine the correlations between these coefficients or the probability of rejection of full insurance (that is whether δ_v is significantly different from 0) and some village characteristics. Also, for comparison purpose, we estimate this equation in the case where no heterogeneity of risk aversion would have been allowed, that is

$$\Delta \ln \widetilde{c}_{it+1} = \Delta \widetilde{z}_{it+1}\alpha + \delta_v \omega_{it+1} + \widetilde{v}_{it+1}$$

A first interesting result is the fact that there is a lot of heterogeneity between villages in the value of the coefficient δ_v and in the rejection probability. Full insurance is not rejected in all villages at the same significance level. At the 5% level, it is rejected only in 30% of villages (10% only when we do not account for heterogeneity of risk aversions), and more rejections occur in the provinces of Sind and the NWFP than in Punjab.

We now examine the determinants of the limits to risk sharing and test some theoretical predictions about the variables that matter for the value of risk sharing within a community like the variability and correlations of income within the community or the degree of risk aversion. We construct measures of the within village correlations across households for variables like income, agricultural income or other characteristics by looking at the correlation between these values for any pair of households belonging to the same village. These measures of correlations are denoted $\rho_{\{i,j\}\in v}$. The following table presents some descriptive statistics of these values:

[TABLE 3 HERE]

Table 4 then shows the regression results of the estimated coefficients δ_v on village characteristics. We also report the probit regressions of the rejection dummy variables (at the 5% level) on these characteristics. We do this both in the case where the δ_v were estimated taking into account the heterogeneity of risk aversion and without heterogeneity. In the village characteristics, we use the preference estimates to compute measures of average risk aversion and heterogeneity of risk aversion for each village. For each village and period, we compute the average risk aversion denoted $\overline{\sigma}_v = \frac{1}{\#\{i\in v\}} \sum_{i\in v} \sigma(z_{it})$ and the variance of risk aversion within the village denoted $var_v\sigma$. The results show that full risk sharing is more likely to be rejected in villages where agricultural incomes are more correlated in which case we know that the value of perfect risk sharing is, everything else equal, lower. Also, the higher is average risk aversion and the more heterogeneous it is, the more likely full risk sharing is rejected. This empirical result is inconsistent with the prediction of section 2.1 that the value of perfect risk sharing within a group of exogenous size increases with the average level of risk aversion. Thus, we can reject the hypothesis where only perfect risk sharing within the village could be obtain and cannot reject that risk sharing groups form endogenously. The imperfect risk sharing observed may be due to perfect risk sharing within a smaller group of endogenous size that is not observed. However, with limited commitment, these empirical results may lead to different inference.

[TABLE 4 HERE]

If the population size of the village is identical to the risk sharing group to which households participate, it is interesting to study its correlation with rejections of full insurance to distinguish whether coalition formations or individual deviations due to limited commitment are the source of imperfect risk sharing. As villages where full insurance is rejected are on average larger, it seems to indicate that not only individual deviations limit risk sharing but also groups of households because of deviations in coalitions.

4 Conclusion

This study of the determinants of the value of informal risk sharing groups allowed to show theoretically the expected effects of heterogeneity of preferences and of limited commitment constraints in risk sharing. We tested several implications on data from rural Pakistan taking into account the heterogeneity of households' preferences. The empirical evidence is consistent with most predictions and show that risk sharing in these village economies seems not to be restricted by coalition formation but rather that risk sharing occurs in sufficiently small groups that form endogenously. Our results show that exogenous size of risk sharing groups can be rejected or that imperfect risk sharing only is obtained within the village because of limited commitment and the risk of coalition formation that needs to be deterred. More empirical research needs to be done, in particular with data allowing to better identify informal risk sharing groups and risk aversion behavior of households.

References

Abreu D. (1988) "On the theory of Infinitely Repeated Games with Discounting", *Econometrica,* 56, 383-396

Alderman H. and Garcia M. (1993) "Poverty, Household Food Security, and Nutrition in Rural Pakistan", *Research Report 96*, IFPRI

Altug S. and Miller R. (1990) "Household Choices in Equilibrium", Econometrica, 58, 3, 543-570

Attanasio, O. and J. V., Ríos-Rull (2003) "Consumption Smoothing and Extended Families", Advances in Economics and Econometrics: Theory and Applications, Volume III: 209-242.

Bound J., Jaeger D. A. and Baker R. (1995) "Problems with Instrumental Variables Estimation when the Correlation between the Instruments and the Endogenous Explanatory Variable is Weak", *Journal of the American Statistical Association*, 90, 443-450

Blundell R., Browning M. and Meghir (1994) "Consumer Demand and the Life-Cycle Allocation of Household Expenditures", *Review of Economic Studies*, 61, 57–80

Browning M. and Meghir C. (1991) "The Effects of Male and Female Labor Supply on Commodity Demands", *Econometrica*, 59, 4, 925-951

Buse A. (1992) "The Bias of Instrumental Variable Estimators" *Econometrica*, 60, 1, 173-80

Cochrane J., (1991) "A Simple Test of Consumption Insurance", *Journal of Political Economy*, 99, 5, 957-976

Coate S. and Ravallion M. (1993) "Reciprocity without commitment - Characterization and Performance of Informal Insurance Arrangements", *Journal of Development Economics*, 40, 1-24

Deaton, A. (1997), *The Analysis of Household Surveys*, The World Bank, John Hopkins: Baltimore.

Deaton A. (1992) *Understanding consumption*, Oxford Clarendon Press

Dubois, P. (2000) "Assurance Parfaite, Hétérogénéité des Préférences et Métayage au Pakistan", *Annales d'Economie et de Statistique, 59, 1-36.*

Fafchamps M. (1992) "Solidarity Networks in Pre-Industrial Societies: Rational Peasants with a Moral Economy", *Economic Development and Cultural Change*, 41, 1, 147-174

Fafchamps M. (1998) "Risk Sharing and Quasi-Credit", *Journal of International Trade and Economic De-*

velopment

Fafchamps M. and Lund S. (2003) "Risk Sharing Networks in Rural Philippines" *Journal of Development Economics*, 71: 261-87, 2003

Fafchamps M. (2004) *Rural Poverty Risk and Development,* Edward Elgar

Foster A. and Rosenzweig M. (2001) "Imperfect Commitment, Altruism and the Family: Evidence from Transfer behavior in Low-Income Rural Areas", *Review of Economics and Statistics*, 83, 3, 389-407

Genicot G. and Ray D. (2003) "Group Formation in Risk-Sharing Arrangements", *Review of Economic Studies*, 70, 1 87–113

Grimard F. (1997) "Household Consumption Smoothing through Ethnic Ties: Evidence from Côte d'Ivoire", *Journal of Development Economics*, 53:391-422

Hayashi F., Altonji J. and Kotlikoff L. (1996) "Risk Sharing Between and Within Families", *Econometrica*, 64, 2, 261-294

Jacoby H. and Skoufias E. (1998) "Testing Theories of Consumption Behavior Using Information on Aggregate Shocks: Income Seasonality and Rainfall in Rural India", *American Journal of Agricultural Economics*, 80, 1-14

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

Kimball M. S. (1988) "Farmers' Cooperatives as Behavior Toward Risk", *American Economic Review*, 78, 1, 224-232

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

Ligon E., Thomas J. and Worrall T. (2002) "Mutual Insurance and Limited Commitment: Theory and Evidence in Village Economies", *Review of Economic Studies, 69, 209-244.*

Mace, B., (1991) "Full Insurance in the Presence of Aggregate Uncertainty", *Journal of Political Economy*, 99, 5, 928-956

Magdalinos M. (1994) "Testing Instrument Admissibility: Some Refined Asymptotic Results", *Econometrica*, 62, 2, 373-403

Meghir C. and Weber G. (1996) “Intertemporal Nonseparability or Borrowing Restrictions? A disaggregate analysis using a US consumption panel”, *Econometrica*, 64, 5, 1151-1181

Murgai R., Winters P., Sadoulet E., and de Janvry A. (1998) Localized and Incomplete Mutual Insurance, *Journal of Development Economics*, 67(2):245-274 (2002)

Paxson C. (1993) “Consumption and Income Seasonality in Thailand”, *Journal of Political Economy*, 101, 39-72

Ravallion M., and Chaudhuri S. (1997) “Risk and Insurance in Village India: Comment”, *Econometrica*, 65:171-184

Rosenzweig M., (1988), “Risk, Implicit Contracts and the Family in Rural Areas of Low Income Countries”, *Economic Journal*, 98, 1148-1170

Rothschild M. and J. Stiglitz (1970) "Increasing Risk I: A Definition", *Journal of Economic Theory*, 2, 225-243

Staiger D. and Stock J. (1997) “Instrumental variables regression with weak instruments”, *Econometrica,* 65, 3, 557–586

Thomas, J., Worrall, T. (1988) “Self Enforcing Wage Contracts”, *Review of Economic Studies*, 55, 541-554

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

Udry, C., (1995), “Risk and Saving in Northern Nigeria”, *Review of Economic Studies*, 61, 3, 495–526

Wilson, R. (1968) “The Theory of Syndicates”, *Econometrica* 36 (1), 119-132

A Appendix

A.1 Proof of Proposition 2

Lemma 7 *Whatever n, the probability distribution of $\overline{y_{n+1}}$ second order stochastically dominates the probability distribution of $\overline{y_n}$.*

Proof. From Theorem 2 of Rothschild and Stiglitz (1970), we know that the random variable X_2 dominates in the second order stochastic sense the random variable X_1 if and only if there exists a random variable ε such that X_1 has the same distribution as $X_2 + \varepsilon$ and $E(\varepsilon | X_2) = 0$. As

$$\begin{aligned} \overline{y_n} &= \frac{1}{n}\sum_{i=1}^{n} y_i = \left(1+\frac{1}{n}\right)\left(\frac{1}{n+1}\sum_{i=1}^{n+1} y_i\right) - \frac{1}{n} y_{n+1} \\ &= \overline{y_{n+1}} + \frac{1}{n(n+1)}\sum_{i=1}^{n+1}\left[y_i - y_{n+1}\right] \end{aligned}$$

and

$$E\left(\sum_{i=1}^{n+1}\left[y_i - y_{n+1}\right] | \overline{y_{n+1}}\right) = \sum_{i=1}^{n+1}\left[E\left(y_i | \overline{y_{n+1}}\right) - E\left(y_{n+1} | \overline{y_{n+1}}\right)\right] = 0$$

because $(y_i)_{i=1,\dots,n+1}$ are assumed identically distributed, $E\left(y_i | \overline{y_{n+1}}\right) = E\left(y_j | \overline{y_{n+1}}\right)$ $\forall j$, $\forall i = 1,..,n+1$. Thus it proves that the probability distribution of $\overline{y_{n+1}}$ second order stochastically dominates the probability distribution of $\overline{y_n}$. ■

The lemma 7, simply implies that $\forall u(.)$, increasing concave $Eu\left(\overline{y_{n+1}}\right) \geq Eu\left(\overline{y_n}\right)$. Then, v_N^c and the difference $v_N^c - v_a$ are an increasing functions of the size of the group N since v_a does not depend on N.

A.2 Proof of Proposition 5

Lemma 8 *With assumptions 1 and 2, $\delta(k,N)$ is increasing in k, N, ρ, decreasing in β, ω^2, σ, and:*

$$\begin{aligned} \lim_{k,N\to\infty} \delta(k,N) &= +\infty \\ \lim_{\beta\to 1} \delta(k,N) &= 0 \\ \lim_{\omega^2\to\infty} \delta(k,N) &= 0 \end{aligned}$$

Actually

$$\delta(k,N) = k\frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\left[\overline{y}-\underline{y}\right]\left[2\left(1/\sigma-\underline{y}\right)-\frac{N+k}{N}\left(\overline{y}-\underline{y}\right)\right] \quad \text{if} \quad \sigma(\overline{y}) \leq \frac{1}{2(\overline{y}-\underline{y})}$$

$$\delta(k,N) = \frac{Nk}{N+k}\frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\left[1/\sigma-\underline{y}\right]^2 \quad \text{if} \quad \sigma\left(\underline{y}\right) \geq \frac{1}{\overline{y}-\underline{y}}$$

$$\delta(k,N) = k\frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\max\left(\frac{N+k}{N}\left[\overline{y}-\underline{y}\right]^2, \left[\overline{y}-\underline{y}\right]\left[2\left(1/\sigma-\underline{y}\right)-\frac{N+k}{N}\left(\overline{y}-\underline{y}\right)\right]\right)$$

$$\text{if} \quad \sigma\left(\underline{y}\right) \leq \frac{1}{(\overline{y}-\underline{y})} \quad \text{and} \quad \sigma(\overline{y}) \geq \frac{1}{2(\overline{y}-\underline{y})}$$

We have $u(\overline{y}_k)-u(\overline{y}_N) = \overline{y}_k-\overline{y}_N+\frac{\sigma}{2}\left[\overline{y}_N^2-\overline{y}_k^2\right] = \left[\overline{y}_N-\overline{y}_k\right]\left[\frac{\sigma}{2}\left[\overline{y}_N+\overline{y}_k\right]-1\right]$ and

$$\begin{aligned}
\max_{\overline{y}_k,\overline{y}_N} u(\overline{y}_k)-u(\overline{y}_N) &= \max_{\overline{y}_k,\overline{y}_N}\left[\overline{y}_N-\overline{y}_k\right]\left[\frac{\sigma}{2}\left[\overline{y}_N+\overline{y}_k\right]-1\right] \\
&= \max_{\overline{y}_k,\overline{y}_N}\left[\frac{k}{N}\overline{y}_k+\frac{N-k}{N}\overline{y}_{N-k}-\overline{y}_k\right]\left[\frac{\sigma}{2}\left[\overline{y}_N+\overline{y}_k\right]-1\right] \\
&= \max_{\overline{y}_k,\overline{y}_{N-k}}\frac{k-N}{N}\left[\overline{y}_k-\overline{y}_{N-k}\right]\left[\frac{\sigma}{2}\left[\frac{k+N}{N}\overline{y}_k+\frac{N-k}{N}\overline{y}_{N-k}\right]-1\right] \\
&= \max_{z_1,z_2\in\left[\underline{y},\overline{y}\right]}\frac{k-N}{N}\left[z_1-z_2\right]\left[\frac{\sigma}{2}\left[\frac{k+N}{N}z_1+\frac{N-k}{N}z_2\right]-1\right]
\end{aligned}$$

So with the result of lemma 4 and noting

$$\delta(k,N) = \max_{z_1,z_2\in\left[\underline{y},\overline{y}\right]}\left\{\frac{k-N}{N}\left[z_1-z_2\right]\left[\frac{\sigma}{2}\left[\frac{k+N}{N}z_1+\frac{N-k}{N}z_2\right]-1\right]\right\}\frac{1-\beta}{\beta}\frac{Nk}{N-k}\frac{2}{\sigma(1-\rho)\omega^2}$$

the condition for k-coalition proofness is indeed $\delta(k,N) \leq 1$. We then introduce the notation $z^* = 1/\sigma-\frac{N+k}{N}\left(\overline{y}-\underline{y}\right)$ to discriminate between three possible cases which lead to a different expression of the maximum function in the definition of $\delta(.)$.

- "Low" Absolute Risk Aversion: $\sigma(\overline{y}) \leq 1/2\left[\overline{y}-\underline{y}\right]$, then $z^* \geq \overline{y}$ and

$$\delta(k,N) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}k\left[\overline{y}-\underline{y}\right]\left[2\left(\frac{1}{\sigma}-\underline{y}\right)-\frac{N+k}{N}\left(\overline{y}-\underline{y}\right)\right]$$

- "High" Absolute Risk Aversion: $\sigma\left(\underline{y}\right) \geq 1/\left[\overline{y}-\underline{y}\right]$, then $z^* \leq \underline{y}$ and

$$\delta(k,N) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\frac{Nk}{N+k}\left[\frac{1}{\sigma}-\underline{y}\right]^2$$

- "Medium" Absolute Risk Aversion: $\sigma\left(\underline{y}\right) \leq 1/\left[\overline{y}-\underline{y}\right]$ and $\sigma(\overline{y}) \geq 1/2\left[\overline{y}-\underline{y}\right]$, then $z^* \in \left[\underline{y},\overline{y}\right]$ and

$$\delta(k,N) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\max\left(k\frac{(N+k)}{N}\left[\overline{y}-\underline{y}\right]^2, k\left[\overline{y}-\underline{y}\right]\left[2\left(\frac{1}{\sigma}-\underline{y}\right)-\frac{N+k}{N}\left(\overline{y}-\underline{y}\right)\right]\right)$$

Actually, with $f(z_1, z_2) = \frac{k-N}{N}[z_1 - z_2]\left[\frac{\sigma}{2}\left[\frac{k+N}{N}z_1 + \frac{N-k}{N}z_2\right] - 1\right]$:

$\frac{\partial f}{\partial z_1}(z_1, z_2){=}f_1(z_1, z_2){=}\sigma\frac{k-N}{N}\left[\frac{k+N}{N}z_1 - \frac{k}{N}z_2 - \frac{1}{\sigma}\right]$ and $\frac{\partial f}{\partial z_2}(z_1, z_2){=}f_2(z_1, z_2){=}\sigma\frac{k-N}{N}\left[\frac{k-N}{N}z_2 - \frac{k}{N}z_1 + \frac{1}{\sigma}\right]$

So $\frac{\partial f}{\partial z_1}(z_1, z_2) = 0 \Leftrightarrow (k+N)z_1 = \frac{N}{\sigma} + kz_2 \Rightarrow z_2(z_1) = \frac{N}{N-k}\left[\frac{1}{\sigma} - \frac{k}{N}z_1\right]$

and $\frac{\partial f}{\partial z_2}(z_1, z_2) = 0 \Leftrightarrow kz_1 + (N-k)z_2 = \frac{N}{\sigma} \Rightarrow z_1(z_2) = \frac{N}{N+k}\left[\frac{1}{\sigma} + \frac{k}{N}z_2\right]$

$f(z_1(z_2), z_2) = \frac{k-N}{N}\left[\frac{N/\sigma+kz_2}{(k+N)} - z_2\right]\left[\frac{\sigma}{2}\left[\frac{k+N}{N}\frac{N/\sigma+kz_2}{(k+N)} + \frac{N-k}{N}z_2\right] - 1\right] = \frac{\sigma}{2}\frac{N-k}{N+k}\left[\frac{1}{\sigma} - z_2\right]^2$

$f(z_1, z_2(z_1)) = \frac{k-N}{N}[z_1 - z_2]\left[\frac{\sigma}{2}\left[\frac{k+N}{N}z_1 + \frac{N-k}{N}z_2\right] - 1\right]$

$\max_{z_2} f(z_1(z_2), z_2) = \frac{\sigma}{2}\frac{N-k}{N+k}\left[\frac{1}{\sigma} - \underline{y}\right]^2$ and $\max_{z_1} f(z_2(z_1), z_1) = \frac{\sigma}{2}\left[\overline{y} - \frac{1}{\sigma}\right]^2$

Therefore, with $\phi(k, N, \sigma, \underline{y}, \overline{y}) = \frac{k-N}{N}\max_{z_1, z_2 \in [\underline{y}, \overline{y}]}[z_1 - z_2]\left[\frac{\sigma}{2}\left[\frac{N+k}{N}z_1 + \frac{N-k}{N}z_2\right] - 1\right]$

If $z^* \in [\underline{y}, \overline{y}] : \phi(k, N, \sigma, \underline{y}, \overline{y}) = \max\left(\frac{\sigma}{2}\frac{N^2-k^2}{N^2}\left[\overline{y} - \underline{y}\right]^2, \frac{\sigma}{2}\frac{N-k}{N}\left[\overline{y} - \underline{y}\right]\left[2\left(\frac{1}{\sigma} - \underline{y}\right) - \frac{N+k}{N}\left(\overline{y} - \underline{y}\right)\right]\right)$

If $z^* < \underline{y} : \phi(k, N, \sigma, \underline{y}, \overline{y}) = \frac{\sigma}{2}\frac{N-k}{N+k}\left[\frac{1}{\sigma} - \underline{y}\right]^2$

If $z^* > \overline{y} : \phi(k, N, \sigma, \underline{y}, \overline{y}) = \frac{\sigma}{2}\frac{N-k}{N}\left[\overline{y} - \underline{y}\right]\left[2\left(\frac{1}{\sigma} - \underline{y}\right) - \frac{N+k}{N}\left(\overline{y} - \underline{y}\right)\right]$

The result of the proposition follows directly from the preceding lemma and the implicit functions theorem. $N^* = \arg\max_N \{N : \forall k < N, \delta(k, N) \leq 1\} = \arg\max_N \{N : \delta(N-1, N) \leq 1\}$. Let $\widetilde{N}^*$ be such that $\delta\left(\widetilde{N}^* - 1, \widetilde{N}^*\right) = 1$, $N^* = I\left[\widetilde{N}^*\right]$ where $I[.]$ is the integer part operator. Thanks to the implicit function theorem $\widetilde{N}^*$ is increasing in β, ω^2, σ, and decreasing in ρ like N^*.

With $\lim_{N\to\infty}\delta(1, N) = \delta(1, \infty) > 0$.

$\delta(1, \infty)$ is decreasing in β, ω^2 and $\lim_{\beta\to 1}\delta(1, \infty) = 0$.

And $\delta(1, N) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\left[\overline{y} - \underline{y}\right]\left[2\left(1/\sigma - \underline{y}\right) - \frac{N+1}{N}\left(\overline{y} - \underline{y}\right)\right]$ if $\sigma(\overline{y}) \leq 1/2\left[\overline{y} - \underline{y}\right]$

$\delta(1, N) = \frac{N}{N+1}\frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\left[1/\sigma - \underline{y}\right]^2$ if $\sigma(\underline{y}) \geq 1/\left[\overline{y} - \underline{y}\right]$

$\delta(1, N) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\max\left(\frac{N+1}{N}\left[\overline{y} - \underline{y}\right]^2, \left[\overline{y} - \underline{y}\right]\left[2\left(1/\sigma - \underline{y}\right) - \frac{N+1}{N}\left(\overline{y} - \underline{y}\right)\right]\right)$ if $\sigma(\underline{y}) \leq 1/\left[\overline{y} - \underline{y}\right]$ and $\sigma(\overline{y}) \geq 1/2\left[\overline{y} - \underline{y}\right]$

$\lim_{N\to\infty}\delta(1, N) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\left[\overline{y} - \underline{y}\right]\left[2\left(1/\sigma - \underline{y}\right) - \left(\overline{y} - \underline{y}\right)\right] > 0$ if $\sigma(\overline{y}) \leq 1/2\left[\overline{y} - \underline{y}\right]$

$\lim_{N\to\infty}\delta(1, N) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\left[1/\sigma - \underline{y}\right]^2 > 0$ if $\sigma(\underline{y}) \geq 1/\left[\overline{y} - \underline{y}\right]$

$\lim_{N\to\infty}\delta(1, N) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\max\left(\left[\overline{y} - \underline{y}\right]^2, \left[\overline{y} - \underline{y}\right]\left[2\left(1/\sigma - \underline{y}\right) - \left(\overline{y} - \underline{y}\right)\right]\right) > 0$ if $\sigma(\underline{y}) \leq 1/\left[\overline{y} - \underline{y}\right]$ and $\sigma(\overline{y}) \geq 1/2\left[\overline{y} - \underline{y}\right]$

$\lim_{N\to\infty}\delta(1, N) = \delta(1, \infty) = \frac{1}{(1-\rho)\omega^2}\frac{1-\beta}{\beta}\left[\overline{y} - \underline{y}\right]\left[2\left(1/\sigma - \underline{y}\right) - \left(\overline{y} - \underline{y}\right)\right] > 0$. Then obviously, $\delta(1, \infty)$ is decreasing in β and $\lim_{\beta\to 1}\delta(1, \infty) = 0$. So $\exists\beta^* < 1$ such that $\delta(1, \infty) \leq 1$ for $\beta \geq \beta^*$.

A.3 Labor Supply

Until now, we have considered that consumption and leisure were separable in households utility functions. As this specification assumption may not be true, non-separability of consumption and leisure can lead to biased estimates if we neglect the household leisure demand or equivalently its labor supply (Browning and Meghir, 1991). Income and hours of labor supply are obviously highly correlated. It seems then important to take into account household labor supply otherwise its omission has similar effects to some unobserved preference shocks correlated with income biasing the income variable coefficient in our regressions. Taking into account the non separability between consumption and leisure we can avoid this problem provided that our specification is correct. For consumption c and labor supply l, we will assume that the utility of household i at time t is of the following form

$$\beta^t u_{it}(c,l) = \exp(\widetilde{z}_{it}\alpha)\frac{c^{1-z_{it}\sigma}}{1-z_{it}\sigma}(1+l)^{-\gamma} \tag{22}$$

where γ is a preference parameter of the household.

The first order condition with respect to consumption remains similar[13] and taking logarithms we get:

$$\Delta \ln c_{it+1} = -z_{it+1}\sigma \ln c_{it+1} + z_{it}\sigma \ln c_{it} - \gamma\Delta \ln l_{it+1} + \Delta\widetilde{z}_{it+1}\alpha + \Delta\eta_{it+1} - \ln \varepsilon_{it+1}$$

A.4 Instrumental Variables

Let's derive the form of instruments under the Null Hypothesis of Full Insurance. We have the following equation

$$\Delta \ln c_{it+1} = \left[-z_{it+1}\ln c_{it+1} + z_{it}\ln c_{it}\right]\sigma + \Delta\widetilde{z}_{it+1}\alpha + v_{it+1} \tag{23}$$

or equivalently

$$\Delta \ln c_{it+1} = \left[-z_{it+1}\Delta \ln c_{it+1} - \ln c_{it}\Delta z_{it+1}\right]\sigma + \Delta\widetilde{z}_{it+1}\alpha + v_{it+1} \tag{24}$$

Besides the variables $[-z_{it+1}\ln c_{it+1} + z_{it}\ln c_{it}]$ of this equation are endogenous while variables $\Delta\widetilde{z}_{it+1}$ are considered as exogenous.

In the case of separability between consumption and leisure, we can write the expectations:

$$(1+z_{it+1}\sigma)\ln c_{it+1} = (1+z_{it}\sigma)\ln c_{it} + \Delta\widetilde{z}_{it+1}\alpha$$

[13] The first order condition with respect to labor supply is not useful for our tests.

Hence

$$\ln c_{it+1} = \frac{1 + z_{it}\sigma}{1 + z_{it+1}\sigma} \ln c_{it} + \frac{\Delta \widetilde{z}_{it+1}\alpha}{1 + z_{it+1}\sigma}$$

and at time t

$$\ln c_{it} = \frac{1 + z_{it-1}\sigma}{1 + z_{it}\sigma} \ln c_{it-1} + \frac{\Delta \widetilde{z}_{it}\alpha}{1 + z_{it}\sigma} \tag{25}$$

Then

$$\ln c_{it+1} = \frac{1 + z_{it}\sigma}{1 + z_{it+1}\sigma} \left[\frac{1 + z_{it-1}\sigma}{1 + z_{it}\sigma} \ln c_{it-1} + \frac{\Delta \widetilde{z}_{it}\alpha}{1 + z_{it}\sigma}\right] + \frac{\Delta \widetilde{z}_{it+1}\alpha}{1 + z_{it+1}\sigma}$$

$$\ln c_{it+1} = \frac{1 + z_{it-1}\sigma}{1 + z_{it+1}\sigma} \ln c_{it-1} + \frac{\Delta^2 \widetilde{z}_{it+1}\alpha}{1 + z_{it+1}\sigma} \tag{26}$$

where Δ^2 is the second difference operator defined by $\Delta^2 X_{t+1} = X_{t+1} - X_{t-1}$.

But according to (24), $[-z_{it+1} \ln c_{it+1} + z_{it} \ln c_{it}]\,\sigma = \Delta \ln c_{it+1} - \Delta \widetilde{z}_{it+1}\alpha$, using (25) and (26), we get:

$$[-z_{it+1} \ln c_{it+1} + z_{it} \ln c_{it}]\,\sigma = \frac{-(1 + z_{it-1}\sigma)\,\Delta z_{it+1}\sigma}{(1 + z_{it+1}\sigma)(1 + z_{it}\sigma)} \ln c_{it-1} + \frac{\Delta^2 \widetilde{z}_{it+1}\alpha}{1 + z_{it+1}\sigma} - \frac{\Delta \widetilde{z}_{it}\alpha}{1 + z_{it}\sigma} - \Delta \widetilde{z}_{it+1}\alpha$$

Writing simply a second order series expansion in σ of these expressions:

We have $\frac{1}{(1+z_{it+1}\sigma)(1+z_{it}\sigma)} = 1 - (z_{it+1} + z_{it})\,\sigma + \left(z_{it}^2 + z_{it+1}z_{it} + z_{it+1}^2\right)\sigma^2 + o\left(\sigma^2\right)$

Hence $\frac{(1+z_{it-1}\sigma)}{(1+z_{it+1}\sigma)(1+z_{it}\sigma)} = 1 - (z_{it+1} + z_{it} - z_{it-1})\,\sigma + o\left(\sigma\right)$

Leading to $\frac{-(1+z_{it-1}\sigma)\Delta z_{it+1}\sigma}{(1+z_{it+1}\sigma)(1+z_{it}\sigma)} = -\Delta z_{it+1}\sigma + \Delta z_{it+1}\left(z_{it+1} + z_{it} - z_{it-1}\right)\sigma^2 + o\left(\sigma^2\right)$

since $\frac{\Delta^2 \widetilde{z}_{it+1}\alpha}{1+z_{it+1}\sigma} - \frac{\Delta \widetilde{z}_{it}\alpha}{1+z_{it}\sigma} = \Delta \widetilde{z}_{it+1}\alpha + [z_{it}\Delta \widetilde{z}_{it} - z_{it+1}\Delta^2 \widetilde{z}_{it+1}]\alpha\sigma + [z_{it+1}^2 \Delta^2 \widetilde{z}_{it+1} - z_{it}^2 \Delta \widetilde{z}_{it}]\alpha\sigma^2 + o\left(\sigma^2\right)$

After some rearrangements and simplifications, we obtain

$$\begin{aligned}[-z_{it+1} \ln c_{it+1} + z_{it} \ln c_{it}]\sigma \underset{\sigma=0}{\sim} & -\Delta z_{it+1}\sigma \ln c_{it-1} + [z_{it}\Delta \widetilde{z}_{it} - z_{it+1}\Delta^2 \widetilde{z}_{it+1}]\alpha\sigma \\ & + \Delta z_{it+1}\left(z_{it+1} + z_{it} - z_{it-1}\right)\sigma^2 \ln c_{it-1} + [z_{it+1}^2 \Delta^2 \widetilde{z}_{it+1} - z_{it}^2 \Delta \widetilde{z}_{it}]\alpha\sigma^2\end{aligned} \tag{27}$$

The following instrumental variables are theoretically valid:

$$-\Delta z_{it+1} \ln c_{it-1}, \qquad z_{it}\Delta \widetilde{z}_{it} - z_{it+1}\Delta^2 \widetilde{z}_{it+1}$$

at the first order, to which we can add at the second order

$$\Delta z_{it+1}\left(z_{it+1} + z_{it} - z_{it-1}\right) \ln c_{it-1}, \qquad z_{it+1}^2 \Delta^2 \widetilde{z}_{it+1} - z_{it}^2 \Delta \widetilde{z}_{it}$$

A.5 Instrumental regressions

In estimation methods with instrumental variables, it is important to present first stage instrumental regressions when an instrumentation method is used (Bound, Jaeger and Baker, 1995, Magdalinos, 1994, Staiger and Stock, 1997). As we cannot present all of them, we show only those concerning the basic within village complete markets hypothesis in the case of consumption leisure separability (Table 5 corresponds to the first step regressions of column (5) of Table 2). Each column of Table 5 is the instrumental regression of one endogenous variable. The instrumental regressions in the case where agricultural income is introduced and where it is instrumented by rental incomes are in Table 6. They correspond to the first step estimation of column (7) in Table 2. Again, all dummy variables are also not shown in these Tables.

[TABLE 5 HERE]

[TABLE 6 HERE]

TABLES

Table 1: Descriptive Statistics

Descriptive statistics on the full sample (all periods)			
Variable	Average	Std Err.	Obs.
Food consumption	197.9	151.4	9990
Other non durable expenditures (heating, ..)	47.3	196.1	9991
Total owned land area (acres)	9.42	21.81	10083
Irrigated land (acres)	4.19	11.25	10083
Non irrigated land (acres)	5.24	17.09	10083
Rented in land under fixed rent (acres)	0.58	3.93	10083
Rented in land under sharecropping (acres)	2.75	6.03	10083
Rented out land under fixed rent (acres)	0.38	3.71	10083
Rented out land under sharecropping (acres)	3.72	14.56	10083
Household size	8.64	4.23	9987
Number of children (<=15years)	4.08	2.91	9987
Wage income	141.9	298.3	9906
Pensions	70.5	450.5	9906
Agricultural profits	109.26	1095.6	9906
Transfers	106	974	9906
Total income (without transfers)	321.7	1291.1	9906
Male labor (person*day/week)	2.62	4.13	9889
Female labor (person*day/week)	0.53	1.89	9885

Table 2: Results of within village full insurance tests

	Dependant variable: $\Delta \ln \widetilde{c}_{it+1}$							
Explanatory variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
σ: z_{it+1}								
Number of children	0.054	0.060	0.042	0.057	0.060	0.072	0.052	0.065
	(1.44)	(1.50)	(1.17)	(1.48)	(2.05)	(2.20)	(1.86)	(2.11)
Household size	-0.018	-0.022	-0.019	-0.031	-0.038	-0.042	-0.038	-0.044
	(0.76)	(0.83)	(0.86)	(1.26)	(2.19)	(2.25)	(2.30)	(2.43)
Irrigated owned land/ad. eq.	-0.012	-0.012	-0.013	-0.012	-0.027	-0.024	-0.031	-0.027
	(0.56)	(0.58)	(0.70)	(0.63)	(1.88)	(1.53)	(2.21)	(1.86)
Seasonal dummies								
1: Winter	-0.104	-0.109	-0.115	-0.133	-0.133	-0.141	-0.141	-0.151
	(1.56)	(1.57)	(1.86)	(2.03)	(2.54)	(2.47)	(2.83)	(2.80)
2: Rabi harvest	-0.029	-0.028	-0.061	-0.058	-0.076	-0.067	-0.098	-0.091
	(0.33)	(0.31)	(0.75)	(0.70)	(1.08)	(0.89)	(1.51)	(1.31)
3: Monsoon	-0.159	-0.149	-0.165	-0.125	-0.169	-0.142	-0.175	-0.152
	(2.20)	(1.58)	(2.44)	(1.39)	(2.94)	(2.22)	(3.20)	(2.51)
4: (reference): Kharif harvest								
α: $\widetilde{z}_{it+1}$								
Number of children	0.295	0.326	0.222	0.308	0.321	0.387	0.278	0.351
	(1.42)	(1.48)	(1.13)	(1.45)	(2.00)	(2.15)	(1.80)	(2.05)
Household size	-0.052	-0.079	-0.060	-0.133	-0.172	-0.196	-0.174	-0.204
	(0.39)	(0.52)	(0.49)	(0.94)	(1.76)	(1.82)	(1.86)	(2.00)
Irrigated owned land/ad. eq.	-0.054	-0.055	-0.064	-0.059	-0.127	-0.110	-0.143	-0.128
	(0.58)	(0.59)	(0.74)	(0.67)	(1.92)	(1.54)	(2.27)	(1.89)
γ								
l^f_{it+1} : Female labor		-0.072		-0.306		-0.231		-0.209
		(0.15)		(0.70)		(1.52)		(1.44)
l^m_{it+1} : Male labor		0.047		0.141		0.073		0.085
		(0.30)		(0.91)		(0.68)		(0.82)
δ: ω_{it+1}								
Agricultural income			$6.47\ 10^{-5}$	$6.61\ 10^{-5}$			$4.44\ 10^{-5}$	$4.50\ 10^{-5}$
			(2.54)	(2.42)			(2.27)	(2.11)
Instruments	[1]	[1]	[1]	[1]	[2]	[2]	[2]	[2]
Inst. labor supply l^m_{it-1}, l^f_{it-1}		*		*		*		*
Degrees of freedom: #	3	3	3	3	12	12	12	12
Sargan statistic: $\chi_2(\#)$	0.225	0.157	1.505	0.864	12.89	8.57	14.90	10.81
Observations	7740	7731	7740	7731	7740	7731	7740	7731

Table 3: Descriptive Statistics

Statistics across villages	Mean	Min.	Max
$\rho_{\{i,j\}\in v}$ owned land	-0.074	-0.24	-0.016
$\rho_{\{i,j\}\in v}$ agr. income	0.139	-0.040	0.677
$\rho_{\{i,j\}\in v}$ total income	0.066	-0.064	0.55
$\rho_{\{i,j\}\in v}$ household size	-0.067	-0.239	0.11
$\rho_{\{i,j\}\in v}$ exogenous income shock	-0.022	-0.174	0.119
$\rho_{\{i,j\}\in v}$ number children	-0.066	-0.243	0.142

Table 4: Results on determinants of full insurance rejection

(robust standard errors)	Homogeneous Preferences		Heterogeneous Preferences	
	OLS	Probit	OLS	Probit
Dependent Variable	δ_v	Reject (1) vs Accept (0)	δ_v	Reject (1) vs Accept (0)
Explanatory Variable				
$\rho_{\{i,j\}\in v}$ owned land	-0.004	-18.347	-0.010	14.827
	(0.005)	(2.868)	(0.003)	(3.822)
$\rho_{\{i,j\}\in v}$ agr. income	-0.030	26.067	-0.008	4.187
	(0.009)	(1.794)	(0.004)	(0.916)
$\rho_{\{i,j\}\in v}$ total income	0.035	-41.145	0.008	-6.755
	(0.012)	(3.474)	(0.006)	(1.248)
$\rho_{\{i,j\}\in v}$ household size	-0.000	32.738	-0.010	-17.715
	(0.006)	(4.823)	(0.004)	(4.876)
$\rho_{\{i,j\}\in v}$ exogenous income	-0.018	0.603	-0.006	-9.066
	(0.009)	(1.680)	(0.004)	(1.860)
$\rho_{\{i,j\}\in v}$ number children	-0.029	-9.562	-0.004	-3.049
	(0.008)	(3.778)	(0.005)	(2.652)
population of village	-	-	$1.6.10^{-7}$	9.10^{-5}
	-	-	(7.10^{-8})	(4.10^{-5})
$\rho_{\{i,j\}\in v}$ agr. income$\times$	-	-	$1.6.10^{-7}$	8.10^{-4}
population	-	-	(4.10^{-7})	(4.10^{-4})
$\overline{\sigma}_v$	0.039	36.263	0.016	6.832
	(0.008)	(2.850)	(0.006)	(1.650)
$var_v\sigma$	-0.043	105.753	-0.008	30.135
	(0.016)	(7.906)	(0.011)	(5.039)
Constant	-0.034	-49.699	-0.018	-10.872
	(0.007)	(3.535)	(0.006)	(1.651)

Table 5: Instrumental regressions

	Instrumented variables [$-z_{it+1}\ln c_{it+1}+z_{it}\ln c_{it}$]					
z_{it+1}	Nb.. of children	Household size	Irrigated land	Winter	Rabi	Monsoon
Explanatory variables						
z_{it+1}			Δz_{it+1}			
Nb. of children	-2.48981	-1.56148	-0.38542	-0.27182	0.04701	-0.20300
	(1.80)	(0.60)	(0.82)	(1.59)	(0.34)	(1.43)
Household size	0.09803	-1.54706	0.02659	0.19602	-0.00702	0.00521
	(0.10)	(0.86)	(0.08)	(1.66)	(0.07)	(0.05)
Irrigated land	-1.58406	-2.42193	-3.39219	-0.22457	-0.00253	-0.09967
	(1.31)	(1.07)	(8.30)	(1.51)	(0.02)	(0.80)
z_{it+1}			$(\Delta z_{it+1})\ln c_{it-1}$			
Nb. of children	-0.49791	0.25229	0.05247	0.04671	-0.00682	0.03658
	(1.93)	(0.52)	(0.60)	(1.47)	(0.26)	(1.38)
Household size	-0.00569	-0.61029	0.01390	-0.03581	0.00267	-0.00386
	(0.03)	(1.84)	(0.23)	(1.64)	(0.15)	(0.21)
Irrigated land	0.36749	0.61096	-0.08021	0.04902	-0.00167	0.03818
	(1.42)	(1.26)	(0.92)	(1.54)	(0.06)	(1.44)
Winter	-0.36648	-0.61409	-0.22240	-0.43938	0.03465	0.01052
	(1.50)	(1.35)	(2.69)	(14.58)	(1.40)	(0.42)
Rabi	0.26855	0.57257	-0.20795	-0.10504	-0.25796	0.02112
	(0.89)	(1.01)	(2.02)	(2.81)	(8.38)	(0.68)
Monsoon	-1.43126	-2.16562	0.00890	-0.01070	-0.00072	-0.43896
	(3.32)	(2.69)	(0.06)	(0.20)	(0.02)	(9.91)
z_{it+1}			$(\Delta z_{it+1})(z_{it+1}+z_{it}-z_{it-1})\ln c_{it-1}$			
Nb. of children	0.00450	-0.02708	0.00454	-0.00528	0.00116	-0.00468
	(0.14)	(0.44)	(0.41)	(1.30)	(0.35)	(1.39)
Household size	-0.00186	0.00538	-0.00505	0.00316	0.00054	-0.00018
	(0.12)	(0.19)	(0.96)	(1.66)	(0.35)	(0.11)
Irrigated land	-0.08031	-0.14621	-0.10005	-0.00655	0.00037	-0.00993
	(1.79)	(1.75)	(6.59)	(1.18)	(0.08)	(2.16)
Winter	0.27402	0.81847	0.13812	0.07848	-0.03179	0.00822
	(1.23)	(1.96)	(1.82)	(2.84)	(1.40)	(0.36)
Rabi	-0.18609	-0.35104	0.23528	0.10310	-0.06799	-0.01950
	(0.59)	(0.59)	(2.18)	(2.63)	(2.11)	(0.60)
Monsoon	1.11738	1.67330	-0.10169	0.02676	0.03370	0.02300
	(2.43)	(1.94)	(0.65)	(0.47)	(0.72)	(0.49)
z_{it+1}			$z_{it}\Delta z_{it} - z_{it+1}\Delta^2 z_{it+1}$			
Nb. of children	0.12186	-0.12102	0.00773	-0.02655	0.00386	-0.02969
	(0.68)	(0.36)	(0.13)	(1.21)	(0.21)	(1.62)
Household size	0.03123	0.16584	-0.01440	0.01582	0.00732	0.00064
	(0.37)	(1.06)	(0.51)	(1.54)	(0.86)	(0.07)
Irrigated land	-0.33064	-0.54969	-0.25307	-0.02540	-0.00062	-0.02993
	(1.57)	(1.40)	(3.55)	(0.98)	(0.03)	(1.38)
z_{it+1}			$z^2_{it+1}\Delta^2 z_{it+1} - z^2_{it}\Delta z_{it}$			
Nb. of children	0.00442	0.00621	-0.00138	0.00055	-0.00019	-0.00046
	(1.13)	(0.85)	(1.04)	(1.14)	(0.48)	(1.16)
Household size	0.00123	0.00278	0.00054	-0.00016	0.00009	0.00020
	(1.04)	(1.26)	(1.35)	(1.11)	(0.78)	(1.68)
Irrigated land	0.00194	0.00537	0.00903	0.00020	0.00001	0.00056
	(1.05)	(1.56)	(14.46)	(0.90)	(0.03)	(2.96)
Observations	7740	7740	7740	7740	7740	7740
R^2	0.58	0.52	0.80	0.14	0.11	0.17

Table 6: Instrumental regressions

	Instrumented variables $[-z_{it+1}lnc_{it+1}+z_{it}lnc_{it}]$						$\Delta\omega_{it+1}$
z_{it+1}	Nb. of children	Household size	Irrigated land	Winter	Rabi	Monsoon	Agr. income
Explanatory variables							
z_{it+1}			Δz_{it+1}				
Nb. of children	-2.489	-1.56	-0.385	-0.271	0.047	-0.203	1392.0
	(1.80)	(0.60)	(0.82)	(1.59)	(0.34)	(1.43)	(1.89)
Household size	0.098	-1.547	0.026	0.196	-0.007	0.005	-79.24
	(0.10)	(0.86)	(0.08)	(1.66)	(0.07)	(0.05)	(0.16)
Irrigated land	-1.58	-2.421	-3.39	-0.224	-0.002	-0.099	-1214.9
	(1.31)	(1.07)	(8.30)	(1.51)	(0.02)	(0.80)	(1.89)
z_{it+1}			$(\Delta z_{it+1})lnc_{it-1}$				
Nb. of children	-0.497	0.252	0.052	0.046	-0.0068	0.036	-310.9
	(1.93)	(0.52)	(0.60)	(1.47)	(0.26)	(1.38)	(2.27)
Household size	-0.005	-0.610	0.0139	-0.0358	0.002	-0.003	49.87
	(0.03)	(1.84)	(0.23)	(1.64)	(0.15)	(0.21)	(0.53)
Irrigated land	0.367	0.610	-0.08	0.049	-0.0016	0.038	295.42
	(1.42)	(1.26)	(0.92)	(1.54)	(0.06)	(1.44)	(2.15)
Winter	-0.366	-0.61409	-0.22240	-0.439	0.034	0.0105	-60.22
	(1.50)	(1.35)	(2.69)	(14.58)	(1.40)	(0.42)	(0.46)
Rabi	0.268	0.57257	-0.20795	-0.105	-0.257	0.0211	-44.221
	(0.89)	(1.01)	(2.02)	(2.81)	(8.38)	(0.68)	(0.27)
Monsoon	-1.431	-2.16	0.008	-0.0107	-0.000	-0.438	113.97
	(3.32)	(2.69)	(0.06)	(0.20)	(0.02)	(9.91)	(0.50)
z_{it+1}			$(\Delta z_{it+1})(z_{it+1}+z_{it}-z_{it-1})lnc_{it-1}$				
Nb. of children	0.0045	-0.027	0.0045	-0.0052	0.0011	-0.0046	5.416
	(0.14)	(0.44)	(0.41)	(1.30)	(0.35)	(1.39)	(0.31)
Household size	-0.0018	0.0053	-0.005	0.0031	0.00054	-0.00018	5.514
	(0.12)	(0.19)	(0.96)	(1.66)	(0.35)	(0.11)	(0.67)
Irrigated land	-0.0803	-0.1462	-0.10	-0.0065	0.0003	-0.009	-50.50
	(1.79)	(1.75)	(6.59)	(1.18)	(0.08)	(2.16)	(2.12)
Winter	0.274	0.818	0.138	0.078	-0.0317	0.008	-27.57
	(1.23)	(1.96)	(1.82)	(2.84)	(1.40)	(0.36)	(0.23)
Rabi	-0.186	-0.351	0.235	0.103	-0.067	-0.019	-84.85
	(0.59)	(0.59)	(2.18)	(2.63)	(2.11)	(0.60)	(0.50)
Monsoon	1.11738	1.67330	-0.10169	0.02676	0.03370	0.02300	-204.1
	(2.43)	(1.94)	(0.65)	(0.47)	(0.72)	(0.49)	(0.83)
z_{it+1}			$z_{it}\Delta z_{it}-z_{it+1}\Delta^2 z_{it+1}$				
Nb. of children	0.12186	-0.12102	0.00773	-0.02655	0.00386	-0.02969	-54.27
	(0.68)	(0.36)	(0.13)	(1.21)	(0.21)	(1.62)	(0.57)
Household size	0.03123	0.16584	-0.01440	0.01582	0.00732	0.00064	59.62
	(0.37)	(1.06)	(0.51)	(1.54)	(0.86)	(0.07)	(1.34)
Irrigated land	-0.33064	-0.54969	-0.25307	-0.02540	-0.00062	-0.02993	-186.8
	(1.57)	(1.40)	(3.55)	(0.98)	(0.03)	(1.38)	(1.67)
z_{it+1}			$z_{it+1}^2\Delta^2 z_{it+1}-z_{it}^2\Delta z_{it}$				
Nb. of children	0.0044	0.00621	-0.00138	0.00055	-0.00019	-0.00046	-3.32
	(1.13)	(0.85)	(1.04)	(1.14)	(0.48)	(1.16)	(1.60)
Household size	0.0012	0.0027	0.00054	-0.00016	0.00009	0.00020	0.788
	(1.04)	(1.26)	(1.35)	(1.11)	(0.78)	(1.68)	(1.26)
Irrigated land	0.0019	0.0053	0.00903	0.00020	0.00001	0.00056	2.190
	(1.05)	(1.56)	(14.46)	(0.90)	(0.03)	(2.96)	(2.23)
Income from rents							0.475
							(12.16)
Observations	7740	7740	7740	7740	7740	7740	7740
R^2	0.58	0.52	0.80	0.14	0.11	0.17	0.02