A Appendix: Assumptions and Proofs

A Assumptions

The model setup uses the following assumptions:

Assumption 1 *All households have a common discount factor β, and common, additively separable utility of per capita consumption and disutility of effort functions $v(c)$ and $z(e)$.*[37] *Utility is increasing and concave in per capita consumption: $v' > 0$ and $v'' < 0$.*

Assumption 2 *Absolute risk aversion is non-increasing:*

$$d\left(\frac{-v''(c_{it})}{v'(c_{it})}\right)/dc_{it} \leq 0 \tag{31}$$

and $lim_{c \to 0^+} u'(c) = \infty$.

Assumption 3 *As long as any household participates in the village insurance network, the household's borrowing and savings decisions are contractible.*

Assumption 4 *Households cannot take savings accumulated while in the insurance network with them into autarky.*

Finally, the following assumptions are made on the production technology:

Assumption 5a *Household output can take on S values. Let r* index an arbitrary income realization, $y_r \in \{y_1, ..., y_S\}$. Indices are chosen so that a higher index means more output.

Assumption 5b *Effort can take on two values in each period, working $(e_t = 1)$ or shirking* $(e_t = 0)$. Effort costs are normalized as:

$$z(1) = z$$
$$z(0) = 0$$

Assumption 5c *For every feasible level of promised utility u, there exists a feasible transfer schedule $\{\tau_{r1}(u)\}$ that delivers, in expectation, exactly $u + z(1)$, gross of effort costs, when high effort is exerted, and a feasible transfer schedule $\{\tau_{r0}(u)\}$ that delivers exactly $u + z(0)$ in expectation when low effort is exerted.*

Assumption 5d *The distribution of a household's income at time t is affected by the household's effort at time t and at time $t-1$.* Conditional on effort choices, income is i.i.d. Thus:

$$\Pr(y_t = y_r) = \pi\left(y_t | e_t, e_{t-1}\right)$$

Assumption 5e *Each of the S income realizations occurs with positive probability under either high or low effort:*

$$\pi\left(y_t|e_t, e_{t-1}\right) \in (0,1), \forall e_t, e_{t-1}, y_t$$

Assumption 5f *Effort at time t ($e_t = 1$) raises expected surplus, regardless of the effort choice at $t-1$:*

$$\sum_{r=1}^{S}\left[\pi\left(y_t|1,1\right) - \pi\left(y_t|0,1\right)\right] y_r > z(1) - z(0)$$

and

$$\sum_{r=1}^{S}\left[\pi\left(y_t|1,0\right) - \pi\left(y_t|0,0\right)\right] y_r > z(1) - z(0), \forall y_{t-1}$$

These assumptions are standard in the literature, with the exception of Assumption 5d. This assumption states that output at time t depends on effort exerted at times t and $t-1$. This is a natural assumption in the context of agricultural households in a developing country. In many agricultural settings output is likely to depend on multiple lags of effort.

Throughout, let λ_{it} be the multiplier on household i's time t promise-keeping constraint, and η_t be the multiplier on the village's time t budget constraint. Let Y^N be the set of possible realizations of incomes for all households in the village, and let the vector of income realizations at time t be $\mathbf{y}_t \in Y^N$. To reduce notation, set $\beta = R = 1$.

B Proof of Proposition 1: Under moral hazard, LIMU is sufficient to predict expected current inverse marginal utility

Planner's problem

The probability $\pi(\mathbf{y}_t|\mathbf{e}_t, \mathbf{e}_{t-1})$ defines the probability of a given set of realizations of household income across all households in the village, $\boldsymbol{y}_t$, when the vector of effort choices at time t was $\mathbf{e}_t$ and the vector of effort choices at time $t-1$ was $\mathbf{e}_{t-1}$. Incomes are independent across households (but not across time). Therefore, $\pi\left(\boldsymbol{y}_t|\mathbf{e}_t, \mathbf{e}_{t-1}\right) = \prod_i \pi\left(y_t|e_t, e_{t-1}\right)$, where $\pi\left(y_t|y_{t-1}, e_t, e_{t-1}\right) = \pi\left(y^t\right)$ is the probability of an individual household's income being y_t given $, e_t, e_{t-1}$.

Conditional on the state $\mathbf{y}_t$, the planner chooses transfers $\tau_t(\mathbf{y}_t) = (\tau_{1t}(\mathbf{y}_t), ..., \tau_{Nt}(\mathbf{y}_t))$, promised utilities $\mathbf{u}_{t+1}(\mathbf{y}_t) = (u_{1,t+1}(\mathbf{y}_t), ..., u_{N-1,t+1}(\mathbf{y}_t))$, threatened utilities $\hat{\mathbf{u}}_{t+1}(\mathbf{y}_t) = (\hat{u}_{1,t+1}(\mathbf{y}_t), ..., \hat{u}_{N,t+1}(\mathbf{y}_t))$ and assets $a_{t+1}(\mathbf{y}_t)$.

To simplify the notation below, in some constraints $u_{N,t+1}(\mathbf{y}_t)$ will be used to denote $u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_{t}$

The planner maximizes the following recursive objective function, which is household N's expected utility at time t.

$$u_N(\mathbf{u}_t, \hat{\mathbf{u}}_t, a_t) = max_{\tau_t(\mathbf{y}_t),\mathbf{u}_{t+1}(\mathbf{y}_t),\hat{\mathbf{u}}_{t+1}(\mathbf{y}_t),a_{t+1}(\mathbf{y}_t)} \sum_{\mathbf{y}_t \in Y^N} \pi(\mathbf{y}_t|\mathbf{e}_t = \mathbf{1}, \mathbf{e}_{t-1}) \times \left(v(y_{it} + \tau_{it}(\mathbf{y}_t) + u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_{t+1}(\mathbf{y}_t)) - z\right) \tag{32}$$

The planner faces the following constraints.

The promise keeping constraints: for every $i < N$, the household must receive its utility promise, u_{it}, in expectation:

$$\sum_{\mathbf{y}_t \in Y^N} \pi(\mathbf{y}_t|\mathbf{e}_t = \mathbf{1}, \mathbf{e}_{t-1} = \mathbf{1})[v(y_{it} + \tau_{it}(\mathbf{y}_t)) + u_{i,t+1}(\mathbf{y}_t)] - z \geq u_{it} \quad \forall \mathbf{y}_t \tag{33}$$

The law of motion of assets:

$$a_{t+1}(\mathbf{y}_t) = a_t - \sum_{i=1}^{N} [\tau_{it}(\mathbf{y}_t) - y_{it}] \quad \forall \mathbf{y}_t \tag{34}$$

The incentive compatibility (IC) constraints, which state for every $i = 1, ..., N$, the household must be indifferent between choosing $e = 1$ rather than $e = 0$:[38]

$$\sum_{\mathbf{y}_t \in Y^N} [\pi(\mathbf{y}_t|\mathbf{e}_t = \mathbf{1}, \mathbf{e}_{t-1} = \mathbf{1}) - \pi(\mathbf{y}_t|e_{it} = 0, \mathbf{e}_{-i,t} = \mathbf{1}, \mathbf{e}_{t-1} = \mathbf{1})][v(y_{it} + \tau_{it}(\mathbf{y}_t)) + u_{i,t+1}(\mathbf{y}_t)] \geq z \tag{35}$$

And the two threat keeping constraints, which place upper bounds on the utility of a household who shirked last period (Fernandes and Phelan, 2000):

1. Threat keeping constraint if the household exerts effort at t, but shirked at $t - 1$: for every $i = 1, ..., N$,

$$\sum_{\mathbf{y}_t} \pi(\mathbf{y}_t|\mathbf{e}_t = \mathbf{1}, e_{i,t-1} = 0, \mathbf{e}_{-i,t-1} = \mathbf{1})[v(y_{it} + \tau_{it}(\mathbf{y}_t)) + u_{i,t+1}(\mathbf{y}_t) - z] \leq \hat{u}_{i,t} \tag{36}$$

2. Threat keeping constraint if the household shirked at t and $t - 1$: for every $i = 1, ..., N$,

$$\sum_{\mathbf{y}_t} \pi(\mathbf{y}_t|e_{i,t} = 0, \mathbf{e}_{-i,t} = \mathbf{1}, e_{i,t-1} = 0, \mathbf{e}_{-i,t-1} = \mathbf{1})[v(y_{it} + \tau_{it}(\mathbf{y}_t)) + \hat{u}_{i,t+1}(\mathbf{y}_t) - z] \leq \hat{u}_{i,t} \tag{37}$$

Notice that the planner implements effort $e_{it} = 1$ for all agents and in all periods along the equilibrium path (Assumption 5f). Thus, the IC constraints (equation 35) assume that agents exerted effort in period $t-1$. The threat keeping constraints (equations 36 and 37) guarantee the time-consistency of the resulting allocation.

Define $h_i(\mathbf{y}_t) = 1 - \frac{\pi(\mathbf{y}_t|e_{it}=0,\mathbf{e}_{-i,t}=1,\mathbf{e}_{t-1}=\mathbf{1})}{\pi(\mathbf{y}_t|\mathbf{e}_{i,t}=1,\mathbf{e}_{t-1}=\mathbf{1})}$ as a measure of the importance of agent i's effort to the realization of $\mathbf{y}_t$. Also, denote the following ratios of probabilities as:

$$r_i^1(\mathbf{y}_t) = \frac{\pi(\mathbf{y}_t|\mathbf{e}_t = 1, e_{i,t-1} = 0, \mathbf{e}_{-i,t-1} = \mathbf{1})}{\pi(\mathbf{y}_t|\mathbf{e}_{i,t} = 1, \mathbf{e}_{t-1} = \mathbf{1})}$$

$$r_i^2(\mathbf{y}_t) = \frac{\pi(\mathbf{y}_t|e_{it} = 0, \mathbf{e}_{-i,t} = \mathbf{1}, e_{i,t-1} = 0, \mathbf{e}_{-i,t-1} = \mathbf{1})}{\pi(\mathbf{y}_t|\mathbf{e}_{i,t} = 1, \mathbf{e}_{t-1} = \mathbf{1})}$$

The term $r_i^1(\mathbf{y}_t)$ is the likelihood ratio for income realization $\mathbf{y}_t$ occurring when household i shirked vs. exerted effort at $t-1$, holding constant high effort by all households at t and high effort by all other households at $t-1$. The term $r_i^2(\mathbf{y}_t)$ is the likelihood ratio for income realization $\mathbf{y}_t$ occurring when household i shirked vs. exerted effort at t and $t-1$, holding constant high effort at t and $t-1$ by all other households.

Then the Lagrangian for the moral hazard problem is:

$$\begin{aligned}
\mathcal{L} = \sum_{\mathbf{y}_t \in Y^N} \pi(\mathbf{y}_t|\mathbf{e}_t = 1, \mathbf{e}_{t-1} = \mathbf{1}) \Big\{ & v(y_{it} + \tau_{it}(\mathbf{y}_t) + u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_{t+1}(\mathbf{y}_t), \mathbf{y}_t) - z \\
& + \sum_{i<N} \lambda_{it}\big(v(y_{it} + \tau_{it}(\mathbf{y}_t)) + u_{i,t+1}(\mathbf{y}_t) - \kappa\big) + \eta_t(\mathbf{y}_t)\big[a_t - \sum_{i=1}^{N}(\tau_{it}(\mathbf{y}_t) - y_{it}) - a_{t+1}(\mathbf{y}_t)\big] \\
& + \sum_{i=1}^{N} \psi_{it}^1\big[r_i^1(\mathbf{y}_t)\big(v(y_{it} + \tau_{it}(\mathbf{y}_t)) + u_{i,t+1}(\mathbf{y}_t) - z\big) - \hat{u}_{i,t}\big] \\
& + \sum_{i=1}^{N} \psi_{it}^2\big[r_i^2(\mathbf{y}_t,)\big(v(y_{it} + \tau_{it}(\mathbf{y}_t)) + \hat{u}_{i,t+1}(\mathbf{y}_t) - z\big) - \hat{u}_{i,t}\big] \\
& + \sum_{i=1}^{N} \varphi_{it}\big[h_i(\mathbf{y}_t)(v(y_{it} + \tau_{it}(\mathbf{y}_t)) + u_{i,t+1}(\mathbf{y}_t)) - z\big] \Big\}
\end{aligned}$$

where λ_{it} is the multiplier on the promise-keeping constraint, φ_{it} is the multiplier on the incentive-compatibility constraint, and ψ_{it}^1 and ψ_{it}^2 are the multipliers on the two threat-keeping constraints.

The problem yields the following first-order conditions:

1. with respect to $\tau_{it}(\boldsymbol{y}_t)$:

$$\big[\lambda_{it} + \varphi_{it} h_i(\mathbf{y}_t) + \psi_{it}^1 r_i^1(\mathbf{y}_t) + \psi_{it}^2 r_i^2(\mathbf{y}_t)\big] v'(y_{it} + \tau_{it}(\mathbf{y}_t)) = \eta_t(\mathbf{y}_t) \tag{38}$$

2. with respect to $u_{i,t+1}(\boldsymbol{y}_t)$:

$$\lambda_{it} + \varphi_{it} h_i(\mathbf{y}_t) + \psi^1_{it} r^1_i(\mathbf{y}_t) = -\big[1 + \phi_{Nt} h_N(\mathbf{y}_t) + \psi^1_{Nt} r^1_N(\mathbf{y}_t) \\ \times \big] \frac{\partial u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_t(\mathbf{y}_t))}{\partial u_{i,t+1}(\boldsymbol{y}_t)} \tag{39}$$

3. with respect to $\hat{u}_{i,t+1}(\boldsymbol{y}_t)$:

$$\psi^2_{it} r^2_i(\mathbf{y}_t) = -\big[1 + \phi_{Nt} h_N(\mathbf{y}_t) + \psi^1_{Nt} r^1_N(\mathbf{y}_t) \\ \times \big] \frac{\partial u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_t(\mathbf{y}_t))}{\partial \hat{u}_{i,t+1}(\boldsymbol{y}_t)} \tag{40}$$

4. with respect to $a_{t+1}(\boldsymbol{y}_t)$:

$$\frac{\partial u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_t(\mathbf{y}_t))}{\partial a_{t+1}} \big[1 + \phi_{Nt} h_N(\mathbf{y}_t) + \psi^1_{Nt} r^1_N(\mathbf{y}_t)\big] = \eta_t(\mathbf{y}_t) \tag{41}$$

and the following three envelope conditions:

$$\frac{\partial u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_t(\mathbf{y}_t))}{\partial a_{t+1}} = \sum_{\mathbf{y}_{t+1} \in Y^N} \pi(\mathbf{y}_{t+1} | \mathbf{e}_{t+1} = \mathbf{1}, \mathbf{e}_t = \mathbf{1}) \eta_{t+1}(\mathbf{y}_{t+1}) \tag{42}$$

$$\frac{\partial u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_t(\mathbf{y}_t))}{\partial u_{i,t+1}} = -\lambda_{i,t+1}(\mathbf{y}_t) \tag{43}$$

$$\frac{\partial u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_t(\mathbf{y}_t))}{\partial \hat{u}_{i,t+1}} = -\psi^1_{i,t+1}(\mathbf{y}_t) - \psi^2_{i,t+1}(\mathbf{y}_t) \tag{44}$$

To show Proposition 1, notice that the first-order condition for transfers (equation 38) can be written as:

$$\lambda_{it} + \varphi_{it} h_i(\mathbf{y}_t) + \psi^1_{it} r^1_i(\mathbf{y}_t) + \psi^2_{it} r^2_i(\mathbf{y}_t) = \frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} \tag{45}$$

and by taking the expectation of equation 45 with respect to time t income, we have that:

$$\lambda_{it} + \psi^1_{it} + \psi^2_{it} = \sum_{\mathbf{y}_t} \pi(\mathbf{y}_t | \mathbf{e}_t = 1, \mathbf{e}_{t-1} = \mathbf{1}) \frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} \tag{46}$$

Note also that by combining the envelope conditions (43) and (44) and the first-order conditions for $u_{it}(\mathbf{y}_t)$ and $\hat{u}_{it}(\mathbf{y}_t)$ (equations 39 and 40), we obtain:

$$\lambda_{it} + \varphi_{it} h_i(\mathbf{y}_t) + \psi^1_{it} r^1_i(\mathbf{y}_t) + \psi^2_{it} r^2_i(\mathbf{y}_t) = \tag{47}$$

$$\left[1 + \phi_{Nt} h_N(\mathbf{y}_t) + \psi^1_{Nt} r^1_N(\mathbf{y}_t)\right] \left(\lambda_{it} + \psi^1_{it} + \psi^2_{it}\right) \tag{48}$$

Therefore, by combining equations 46 and 47, the solution satisfies:

$$\frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} = \left[1 + \phi_{Nt} h_N(\mathbf{y}_t) + \psi^1_{Nt} r^1_N(\mathbf{y}_t)\right] \tag{49}$$

$$\left[\times \sum_{\mathbf{y}_{t+1}} \pi(\mathbf{y}_{t+1} | \mathbf{e}_{t+1} = 1, \mathbf{e}_t = \mathbf{1}) \frac{\eta_{t+1}(\mathbf{y}_{t+1})}{v'(y_{i,t+1} + \tau_{i,t+1}(\mathbf{y}_{t+1}))}\right]$$

or, rearranging,

$$\frac{1}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} = \sum_{\mathbf{y}_{t+1}} \pi(\mathbf{y}_{t+1} \mathbf{e}_{t+1} = 1, \mathbf{e}_t = \mathbf{1}) \frac{\tilde{\eta}_{t+1}(\mathbf{y}_{t+1})}{v'(y_{i,t+1} + \tau_{i,t+1}(\mathbf{y}_{t+1}))} \tag{50}$$

$$= \mathbb{E} \frac{\tilde{\eta}_{t+1}(\mathbf{y}_{t+1})}{v'(y_{i,t+1} + \tau_{i,t+1}(\mathbf{y}_{t+1}))} \tag{51}$$

which is the inverse Euler equation. The left-hand side is lagged inverse marginal utility, while the right-hand side consists of the expectation of the product between the inverse marginal utility and a village-year fixed effect, $\tilde{\eta}_{t+1}(\mathbf{y}_{t+1}) = \frac{\eta_{t+1}(\mathbf{y}_{t+1})}{\eta_t(\mathbf{y}_t)} \left[1 + \phi_{Nt} h_N(\mathbf{y}_t) + \psi^1_{Nt} r^1_N(\mathbf{y}_t)\right]$.■

C Proof of Proposition 2: LIMU is sufficient for forecasting expected current inverse marginal utility under limited commitment

Planner's problem

Because effort is contractible in the limited commitment model and high effort is always implemented (Assumption 5f), the dependence of output on current and past effort is suppressed to avoid additional notation. The cost of effort is also suppressed, so that the promised utilities are interpreted as net of effort costs. Therefore denote $\pi(\mathbf{y}_t | \mathbf{e}_t = \mathbf{1}, \mathbf{e}_{t-1} = \mathbf{1})$ by $\pi(\mathbf{y}_t)$, which defines the probability of a given set of realizations of household income across all households in the village, $\boldsymbol{y}_t$. Incomes are independent across households. Therefore, $\pi(\boldsymbol{y}_t) = \prod_i \pi(y_t)$, where $\pi(y_t) = \pi(y^t)$ is the probability of an individual household's income being y_t and hence of history y^t.

To guarantee differentiability of the planner's value function (**?**), the following assumption is made:

Assumption A.1: There is at least one realization $\boldsymbol{y}_t$ such that no household's participation constraint is binding.

The planner maximizes the following recursive objective function, which is household N's expected utility at time t.

$$u_N\left(\boldsymbol{u}_t, a_t\right) \equiv \max_{\{\tau_{it}(\boldsymbol{y}_t)\},\{u_{i,t+1}(\boldsymbol{y}_t)\}} \sum_{y_t} \pi\left(\boldsymbol{y_t}\right)\left\{v\left(y_{Nt}(\boldsymbol{y}_t)+\tau_{Nt}(\boldsymbol{y}_t)\right)+u_N\left(\boldsymbol{u}_{t+1}(\boldsymbol{y}_t), a_{t+1}(\boldsymbol{y}_t)\right)\right\}$$

The maximization is subject to the following constraints:

The promise-keeping constraints

$$\sum_{\mathbf{y}_t} \pi\left(\boldsymbol{y}_t | \boldsymbol{y}_{t-1}\right)\left\{v\left(y_{it}+\tau_{it}(\boldsymbol{y}_t)\right)+u_{i,t+1}(\boldsymbol{y}_t)\right\}=u_{it}, \forall i<N \tag{52}$$

The law of motion for assets:

$$a_{t+1}(\boldsymbol{y}_t)=a_t+\sum_{i=1}^{N}(y_{it}-\tau_{it}(\boldsymbol{y}_t)) \tag{53}$$

And the participation constraints

$$v\left(y_{it}+\tau_{it}(\boldsymbol{y}_t)\right)+u_{it+1}(\boldsymbol{y}_t) \geq U^{aut}\left(y_{it}, 0\right), \forall \boldsymbol{y}_t, i \tag{54}$$

The value of entering autarky with income y_{it} is given by

$$\begin{aligned} U^{aut}\left(y_{it}, 0\right) \equiv & \max_{w} u(y_{it}-w) \\ & +\sum_{y_{t+1}} \pi\left(y_{t+1}\right)\left[U^{aut}\left(y_{t+1}, w\right)\right] \end{aligned} \tag{55}$$

reflecting the assumption that households enter autarky with no savings $(w=0)$, but thereafter can borrow and save at gross rate $R=1$.[39]

The Lagrangian for the planner's problem is:

$$\mathcal{L} = \sum_{\mathbf{y}_t} \pi(\mathbf{y}_t) \Big\{ v(y_{Nt} + \tau_{Nt}(\mathbf{y}_t) + u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), a_{t+1}(\mathbf{y}_t)) \tag{56}$$

$$+ \sum_{i<N} \lambda_{it} \big(v(y_{it} + \tau_{it}(\mathbf{y}_t)) + u_{i,t+1}(\mathbf{y}_t) - u_{i,t} \big)$$

$$+ \eta_t(\mathbf{y}_t) \big[a_t - \sum_{i=1}^{N} (\tau_{it}(\mathbf{y}_t) - y_{it}) - a_{t+1}(\mathbf{y}_t) \big]$$

$$+ \sum_{i=1}^{N} \phi_{it}(\mathbf{y}_t) \big[v(y_{it} + \tau_{it}(\mathbf{y}_t) + u_{i,t+1}(\mathbf{y}_t) - U^{aut}(y_{it}, 0) \big] \Big\}$$

Call the multiplier on household i's time t promise-keeping constraint λ_{it}, denote the multiplier on the participation constraint in state $\boldsymbol{y}_t$ as $\phi_{it}(\boldsymbol{y}_t)$ and denote the multiplier on the resource constraint in state $\boldsymbol{y}_t$ as $\eta_t(\boldsymbol{y}_t)$. The solution is characterized by the following first order conditions:

1. with respect to $\tau_{it}(\mathbf{y}_t)$:

$$\eta(\boldsymbol{y}_t) = (\lambda_{it} + \phi_{it}(\boldsymbol{y}_t)) v'(y_{it} + \tau_{it}(\boldsymbol{y}_t)) \tag{57}$$

2. with respect to $u_{i,t+1}(\mathbf{y}_t)$:

$$\frac{\partial u_N(\mathbf{u}_{t+1}, a_{t+1})}{\partial u_{i,t+1}(y_{irt})} = -\lambda_{it} - \phi_{it}(\boldsymbol{y}_t), \forall y_i, i < N \tag{58}$$

3. with respect to $a_{t+1}(\boldsymbol{y}_t)$:

$$\frac{\partial u_N(\mathbf{u}_{t+1}(\boldsymbol{y}_t), a_{t+1})}{\partial a_{t+1}(\boldsymbol{y}_t)} = \eta_t(\boldsymbol{y}_t) \tag{59}$$

and the envelope condition for current promises:

$$\frac{\partial u_N(\mathbf{u}_t, a_t)}{\partial u_{it}(\boldsymbol{y}_{t-1})} = -\lambda_{it}, \forall i < N \tag{60}$$

and the envelope condition for and assets:

$$\frac{\partial u_N(\mathbf{u}_t, a_t)}{\partial a_t(\boldsymbol{y}_{t-1})} = \eta_{t-1}(\boldsymbol{y}_{t-1}) \tag{61}$$

Advancing the envelope condition for $u_{it}(\mathbf{y}_{t-1})$, equation (60), by one period, yields:

$$\frac{\partial u_N(\mathbf{u}_{t+1}, a_{t+1})}{\partial u_{i,t+1}(\boldsymbol{y}_t)} = -\lambda_{i,t+1}(\mathbf{y}_t), \forall i < N \tag{62}$$

Combining the first-order condition for $u_{i,t+1}(\mathbf{y}_t)$,equation (58) and equation (62) we have that the time $t+1$ promise-keeping multiplier is equal to the time t promise-keeping multiplier plus the time t participation constraint multiplier:

$$\lambda_{i,t+1}(\mathbf{y}_t) = \lambda_{it} + \phi_{it}(\mathbf{y}_t) \tag{63}$$

Using the first-order condition for $\tau_{it}(\mathbf{y}_t)$, equation (57), it follows that the time $t+1$ promise-keeping multiplier is also equal to time t inverse marginal utility, scaled by the time t multiplier on the budget constraint:

$$\frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} = \lambda_{it} + \phi_{it}(\mathbf{y}_t) = \lambda_{i,t+1}(\mathbf{y}_t) \tag{64}$$

Lagging equation (64) yields:

$$\frac{\eta_{t-1}}{v'(y_{i,t-1} + \tau_{i,t-1})} = \lambda_{it} \tag{65}$$

Combining equations (64) and (65) and rearranging, we can write:

$$\frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} - \frac{\eta_{t-1}}{v'(y_{i,t-1} + \tau_{i,t-1})} = \lambda_{i,t+1}(\mathbf{y}_t) - \lambda_{it} = \phi_{it}(\mathbf{y}_t) \tag{66}$$

In words, the innovation to inverse marginal utility (scaled by the multiplier on the budget constraint) is equal to the innovation to the promise-keeping multiplier. That innovation, in turn, is the time t participation constraint multiplier. Rewrite equation (66) as:

$$\frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} = \frac{\eta_{t-1}}{v'(y_{i,t-1} + \tau_{i,t-1})} + \phi_{it}(\mathbf{y}_t)$$

Thus,

$$\mathbb{E}\left(\frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} | \frac{1}{v'(y_{i,t-1} + \tau_{i,t-1})}, \eta_t(\mathbf{y}_t)\right) = \frac{\eta_{t-1}}{v'(y_{i,t-1} + \tau_{i,t-1})}$$

since, conditional on $\left(\frac{1}{v'(y_{i,t-1}+\tau_{i,t-1})}, \eta_t(\mathbf{y}_t)\right)$, $\phi_{it}(\mathbf{y}_t)$ is an innovation, not forecastable based on time $t-1$ information since, as noted by (Ligon et al. 2002, p 215), the participation constraints of the limited commitment model are forward looking, and therefore the set of sustainable continuation contracts depends only on the current state. It is necessary to condition on $\frac{1}{v'(y_{i,t-1}+\tau_{i,t-1})}$ since, to the extent that y_{it} contains "good news" about future income, this is reflected in the household's time t transfer, hence inverse marginal utility.

Therefore lagged inverse marginal utility, conditional on the current shadow price of resources $\eta_t(\mathbf{y}_t)$, captures all past information relevant to forecasting the expectation of current marginal utility of consumption.■

D Proof of proposition 3: Under hidden income, LIMU is not sufficient to predict expected current inverse marginal utility

Because effort is contractible in the hidden income model and high effort is always implemented (Assumption 5f), the dependence of output on current and past effort is suppressed to avoid additional notation. The cost of effort is also suppressed, so that the promised utilities are interpreted as net of effort costs. Therefore denote $\pi(\mathbf{y}_t|, \mathbf{e}_t = \mathbf{1}, \mathbf{e}_{t-1} = \mathbf{1})$ by $\pi(\mathbf{y}_t)$, which defines the probability of a given set of realizations of household income across all households in the village, $\boldsymbol{y}_t$. Incomes are independent across households. Therefore, $\pi\left(\boldsymbol{y}_t\right) = \prod_i \pi\left(y_t\right)$, where $\pi\left(y_t\right) = \pi\left(y^t\right)$. Because it is relevant to keep track of the index (r) of household $i's$ income realization, the probability that household i will realize income $y_{it} = y_r$ and that the rest of the village will realize the vector of incomes $\boldsymbol{y}_{-i,t}$, is denoted $\pi\left(y_{irt}, \boldsymbol{y}_{-i,t}\right)$.

The planner maximizes the following recursive objective function, which is household N's expected utility at time t.

$$u_N\left(\boldsymbol{u}_t, a_t\right) \equiv \max_{\{\tau_{it}(\boldsymbol{y}_t)\},\{u_{i,t+1}(\boldsymbol{y}_t)\}} \sum_{y_t} \left\{\pi(y_{Nrt}, \boldsymbol{y}_{-N,t})\left(y_{Nt}(\boldsymbol{y}_t) + \tau_{Nt}(\boldsymbol{y}_t)\right) + u_N\left(\boldsymbol{u}_{t+1}(\boldsymbol{y}_t), a_{t+1}\right)\right\} \tag{67}$$

The maximization is subject to the following constraints:

The promise-keeping constraints for households $i < N$:

$$\sum_{y_t} \pi\left(y_{irt}, \boldsymbol{y}_{-i,t}\right)\left\{v\left(y_{it} + \tau_{it}(\boldsymbol{y}_t)\right) + u_{i,t+1}(\boldsymbol{y}_t)\right\} = u_{it} \tag{68}$$

the law of motion for assets:

$$a_{t+1}(\boldsymbol{y}_t) = a_t + \sum_{i=1}^{N}(y_{it} - \tau_{it}(\boldsymbol{y}_t)) \tag{69}$$

and the set of interim truth-telling constraints.[40] The local downward truth-telling constraints are binding **(?)**: for every income realization r (but the lowest) and every household i, the household realizing y_{irt} must prefer to truthfully report y_{irt} and receive transfer $\tau_{it}(y_{irt}, \boldsymbol{y}_{-i,t})$ and promise $u_{i,t+1}(y_{irt}, \boldsymbol{y}_{-i,t})$ associated with the actual income realization, rather than claiming their income was the lower one $y_{i,r-1,t}$ and getting transfer $\tau_{it}(y_{i,r-1,t}, \boldsymbol{y}_{-i,t})$ and promise $u_{i,t+1}(y_{i,r-1,t}, \boldsymbol{y}_{-i,t})$:

$$v(y_{irt} + \tau_{it}(y_{irt}, \boldsymbol{y}_{-i,t})) + u_{i,t+1}(y_{irt}, \boldsymbol{y}_{-i,t}) - v(y_{irt} + \tau_{it}(y_{i,r-1,t}, \boldsymbol{y}_{-i,t})) - u_{i,t+1}(y_{i,r-1,t}, \boldsymbol{y}_{-i,t}) \geq 0 \tag{70}$$

Let the Lagrange multiplier associated with the truth-telling constraint for a household realizing income r at time t be ξ_{irt}. The Lagrangian is:

$$\begin{aligned} L = &\sum_{\boldsymbol{y}_t} \pi(\boldsymbol{y}_t)\{v(y_{Nt} + \tau_{Nt}(\boldsymbol{y}_t) + u_N(\boldsymbol{u}_{t+1}(\boldsymbol{y}_t), a_{t+1}(\boldsymbol{y}_t)) \\ &+ \sum_{i<N} \lambda_{it}[v(y_{it} + \tau_{it}(\boldsymbol{y}_t)) + u_{i,t+1}(\boldsymbol{y}_t) - u_{it}(\mathbf{y}_{t-1})] \\ &+ \eta_t(\boldsymbol{y}_t)[a_t + \sum_{i=1}^{N}(y_{it} - \tau_{it}(\boldsymbol{y}_t)) - a_{t+1}(\boldsymbol{y}_t)]\} \\ &+ \sum_i \xi_{irt}[v(y_{irt} + \tau_{it}(\boldsymbol{y}_t)) + u_{i,t+1}(\boldsymbol{y}_t) - v(y_{irt} + \tau_{it}(y_{i,r-1,t}, \boldsymbol{y}_{-i,t})) - u_{i,t+1}(y_{i,r-1,t}, \boldsymbol{y}_{-i,t})] \end{aligned} \tag{71}$$

Therefore, the solution is characterized by the following first order conditions:

1. with respect to $a_{t+1}(\boldsymbol{y}_t)$:

$$\eta_t(\boldsymbol{y}_t) = \frac{\partial u_N(\boldsymbol{u}_{t+1}(\boldsymbol{y}_t), a_{t+1}(\boldsymbol{y}_t))}{\partial a_{t+1}(\boldsymbol{y}_t)} \tag{72}$$

2. with respect to $u_{i,t+1}(\boldsymbol{y}_t)$:

$$-\pi\left(y_{irt}, \boldsymbol{y}_{-i,t}\right) \frac{\partial u_N(\boldsymbol{u}_{t+1}(\boldsymbol{y}_t), a_{t+1}(\boldsymbol{y}_t))}{\partial u_{i,t+1}(\boldsymbol{y}_t)} = \pi\left(y_{irt}, \boldsymbol{y}_{-i,t}\right) \lambda_{it} + \zeta_{irt} - \zeta_{i,r+1,t} \tag{73}$$

3. with respect to $\tau_{it}(\boldsymbol{y}_t)$:

$$\begin{aligned} &\pi(\boldsymbol{y}_t)\eta_t(\boldsymbol{y}_t) = [\pi(\boldsymbol{y}_t)\lambda_{it} + \xi_{irt}]v'(y_{irt} + \tau_{it}(y_{irt}, \boldsymbol{y}_{-i,t})) \\ &- \xi_{i,r+1,t}v'(y_{i,r+1,t} + \tau_{it}(y_{irt}, \boldsymbol{y}_{-i,t})) \end{aligned} \tag{74}$$

and the two Envelope conditions:

$$\frac{\partial u_N(\mathbf{u}_t, a_t)}{\partial a_t(\boldsymbol{y}_{t-1})} = \eta_{t-1}(\boldsymbol{y}_{t-1}) \tag{75}$$

and

$$\frac{\partial u_N(\mathbf{u}_t, a_t)}{\partial u_{it}(\boldsymbol{y}_{t-1})} = -\lambda_{it}, \forall i\ < N \tag{76}$$

The FOC for $u_{ir,t+1}$ (73) and the envelope condition for u_{it} (76) imply

$$\lambda_{i,t+1} = \lambda_{it} + \frac{\xi_{irt} - \xi_{i,r+1,t}}{\pi\left(y_{irt}, \boldsymbol{y}_{-i,t}\right)} \tag{77}$$

or, lagging equation (77) by one period, and denoting the time $t-1$ realized income level as y_p :

$$\lambda_{it} = \lambda_{i,t-1} + \frac{\xi_{ip,t-1} - \xi_{i,p+1,t-1}}{\pi\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right)} \tag{78}$$

The FOCs for time $t-1$ transfers awarded to households announcing incomes of $y_{ip,t-1}$ and $y_{i,p+1,t-1}$ imply that

$$\lambda_{i,t-1} = \frac{\eta_{t-1}}{v'(y_{ip,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right))}\times \left(1 - \frac{\xi_{ip,t-1}v'(y_{ip,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right) - \xi_{i,p+1,t-1}v'(y_{i,p+1,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right))}{\eta_{t-1}\pi\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right)}\right)$$

Since, unconditionally, λ_{it} is a martingale **(?)**, $\lambda_{i,t-1} = \mathbb{E}(\lambda_{it}|\eta_t)$. Therefore:

$$\mathbb{E}(\lambda_{it}|\eta_t) = \frac{\eta_{t-1}}{v'(y_{ip,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right))}\times \left(1 - \underbrace{\frac{\xi_{ip,t-1}v'(y_{ip,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right) - \xi_{i,p+1,t-1}v'(y_{i,p+1,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right))}{\eta_{t-1}\pi\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right)}}_{\equiv\theta_{ip}(\boldsymbol{y}_{t-1})}\right) \tag{79}$$

That is, the term

$$\theta_{ipt}(\boldsymbol{y}_{t-1}) \equiv \frac{\xi_{ip,t-1}v'(y_{ip,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right) - \xi_{i,p+1,t-1}v'(y_{i,p+1,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right))}{\eta_{t-1}\pi\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right))} \tag{80}$$

is the wedge between LIMU (scaled by η_{t-1}) and the expectation of current inverse marginal utility.

As long as the wedge $\theta_{ip}(\boldsymbol{y}_{t-1})$ is non-degenerate, that is, $\frac{\partial\theta_{ip}(\boldsymbol{y}_{t-1})}{\partial y_{ip,t-1}} \neq 0$, LIMU and η_t are not sufficient to forecast future consumption.

To see that $\frac{\partial\theta_{ip}(\boldsymbol{y}_{t-1})}{\partial y_{ip,t-1}} \neq 0$, note that the marginal utility of the household when truthfully claiming income $y_{ip,t-1}$ is higher than that of the household when claiming income $y_{ip,t-1}$ but actually receiving income $y_{i,p+1,t-1}$:

$$v'(y_{ip,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right)) >' \left(y_{i,p+1,t-1} + \tau_{i,t-1}\left(y_{ip,t-1}, \boldsymbol{y}_{-i,t-1}\right)\right) \tag{81}$$

There is no truth-telling constraint associated with the lowest income level y_1 (because there is no lower income level which can be claimed) and there is no truth-telling constraint associated with the the $(S+1)\,th$ income level (since the highest possible income is y_S) ((**?**), p 668). Thus

$$\sum_{s=1}^{S}\left(\xi_{i,s+1,t-1}-\xi_{i,s,t-1}\right)=\xi_{i,S+1,t-1}-\xi_{i,1,t-1}=0 \tag{82}$$

So on average $\xi_{ip,t-1}=\xi_{i,p+1,t-1}$.

From equation (78),

$$\lambda_{it}-\lambda_{i,t-1}=\frac{\xi_{ip,t-1}-\xi_{i,p+1,t-1}}{\pi\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}|\boldsymbol{y}_{t-2}\right)}. \tag{83}$$

That is, if λ_{it} (the promise-keeping multiplier based on the $t-1$ income realization) is, on average greater than $\lambda_{i,t-1}$ (the promise-keeping multiplier based on the $t-2$ income realization), then $\xi_{ip,t-1}>\xi_{i,p+1,t-1}$, that is the truth-telling constraint associated with income $y_{ip,t-1}$ is tighter than that associated with income $y_{ip,t-1}$. Thus $\xi_{ip,t-1}>\xi_{i,p+1,t-1}$ when y_p is a better-than-average income draw. When $y_p<\bar{y}$, the opposite is true: $\xi_{ip,t-1}<\xi_{i,p+1,t-1}$.■

The sign of $\frac{\partial\theta_{ip}(\boldsymbol{y}_{t-1})}{\partial y_{ip,t-1}}$ can be determined when the condition of Corollary 4 is satisfied. That is, when:

$$\begin{aligned}&\frac{v'(y_{ip,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)-v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right))}{v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right))}\\&>\frac{\xi_{i,p,t-1}-\xi_{i,p+1,t-1}}{\xi_{i,p+1,t-1}},\forall p\in\{1,S-1\}\end{aligned}$$

implying that equilibrium marginal utility falls, in percentage terms, more quickly with income than promise-keeping constraints tighten with income:

1 Proof of Corollary 4: If equilibrium marginal utility falls more quickly with income than promise-keeping constraints tighten with income, inverse marginal utility will be positively correlated with past income:

Proof: Rewrite the numerator of $\theta_{ip}(\boldsymbol{y}_{t-1})$ (eq 80) by adding and subtracting $\xi_{ip,t-1}v'(y_{ip,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)$. The sign of $\theta_{ip}(\boldsymbol{y}_{t-1})$ is the sign of:

$$\begin{aligned}&\xi_{ip,t-1}\left[v'(y_{ip,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)-v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)\right]\\&-\left[\xi_{i,p+1,t-1}-\xi_{ip,t-1}\right]v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)\end{aligned} \tag{84}$$

Dividing by $\xi_{ip,t-1}v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)$, which is strictly positive for $p\in\{2,...,S\}$, $\theta_{ip}(\boldsymbol{y}_{t-1})>0$ if

$$\frac{v'(y_{ip,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)-v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)}{v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)}>\frac{\xi_{i,p,t-1}-\xi_{i,p+1,t-1}}{\xi_{i,p+1,t-1}}. \tag{85}$$

That is, if the equilibrium marginal utility levels associated with income levels grow faster, in percentage terms, than the truth-telling constraints associated with those income levels, then $\frac{\partial\theta_{ip}(\boldsymbol{y}_{t-1})}{\partial y_{ip,t-1}}>0$.

Substitute the envelope condition for $u_{i,t-1}$, equation (76) into equation (83). The magnitude of $\xi_{i,p,t-1}-\xi_{i,p+1,t-1}$ is given by:

$$\begin{aligned}&\pi\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)\left[\frac{\partial u_N(\mathbf{u}_{t-1},a_{t-1},\mathbf{y}_{t-2})}{\partial u_{i,t-1}}-\mathbb{E}\left(\frac{\partial u_N(\mathbf{u}_t,a_t,\mathbf{y}_{t-1})}{\partial u_{it}}|\eta_t,y_{t-1}\right)\right] \\ &=\xi_{i,p,t-1}-\xi_{i,p+1,t-1}.\end{aligned} \tag{86}$$

If the cost to the planner/village of providing i with utility rises more slowly with income than i's marginal utility falls with income, the lemma will be satisfied. Since, by assumption, the village has access to a credit technology which individuals cannot privately use, the cost to the village of increasing i's utility (reducing marginal utility) grows more slowly than marginal utility falls, because the village can borrow and save to smooth the costs across time.■

E Proof of proposition 5: Less-variable income processes display a reduced wedge between LIMU and current inverse marginal utility

Proof: The term $\theta_{ip}(\boldsymbol{y}_{t-1})$, defined in (80) measures the "wedge" between λ_{it} and $\frac{\eta_{t-1}}{v'(y_{ip,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right))}$. Take the expectation of $\left|\theta_{ip}(\boldsymbol{y}_{t-1})\right|$ with respect to the time $t-1$ income realization $\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)$:

$$\begin{aligned}\mathbb{E}\left[|\theta(y_p)|\right]=&\sum_{p=1}^{S}\pi\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)\\ &\times\left|\frac{\xi_{ip,t-1}v'(y_{ip,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)-v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)}{\eta_{t-1}\pi\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)}\right|\end{aligned}$$

Fixing the probability of each income realization, $\pi\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)$, a SOSD reduction in variability will reduce the quantity

$$\mathbb{E}\left|v'(y_{ip,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)-v'(y_{i,p+1,t-1}+\tau_{i,t-1}\left(y_{ip,t-1},\boldsymbol{y}_{-i,t-1}\right)\right|$$

since income levels are closer together (note these differences remain negative since $y_p < y_{p+1}$), and will reduce $\mathbb{E}\left|\xi_{ip,t-1} - \xi_{i,p+1,t-1}\right|$ by (86) since a reduction in the amount of uncertainty about the household's income moves $\mathbb{E}u_{it}$ and $u_{i,t-1}$closer together (insurance improves). By the concavity of the planner's value function, this in turn reduces the gap $\frac{\partial u_N(\mathbf{u}_{t-1},a_{t-1},\mathbf{y}_{t-2})}{\partial u_{i,t-1}} - \mathbb{E}\left(\frac{\partial u_N(\mathbf{u}_t,a_t,\mathbf{y}_{t-1})}{\partial u_{it}}|\eta_t, y_{t-1}\right)$. Therefore, $\mathbb{E}\left[\theta_{ip}(\boldsymbol{y}_{t-1})\right] \to 1$ as the variability of y decreases, so that the amount of additional information contained in y_{t-1} falls.■

F Proof of proposition 6: Different components of income affect consumption in adjacent periods proportionally under limited commitment or moral hazard

Proposition 6 states that for any components of lagged income $x^k_{i,t-s}$, which predict (or are components of) lagged income, the following proportionality restriction will hold:

$$\frac{d\ln c_{it}}{dx^k_{i,t-s}} / \frac{d\ln c_{i,t-1}}{dx^k_{i,t-s}} = \pi_i, \forall k$$

even if household differ in their utility functions ($v_i'(y_r+\tau_{irt}) \neq v_j'(y_r+\tau_{irt})$ or $\beta_i \neq \beta_j$) and if observed consumption is measured with (possibly non-classical) error.

Under limited commitment, inverse marginal utility, through transfers, is determined according to FOC for transfers, equation (57):

$$\frac{\eta\left(\boldsymbol{y}_t\right)}{\lambda_{it} + \phi_{it}\left(\boldsymbol{y}_t\right)} = -\lambda_{it} - \phi_{it}\left(\boldsymbol{y}_t\right)$$

and the future promise according to its FOC, equation (58):

$$-\frac{\partial u_N(\mathbf{u}_{t+1}, a_{t+1}, \boldsymbol{y}_t)}{\partial u_{i,t+1}(y_{irt})} = -\lambda_{it} - \phi_{it}\left(\boldsymbol{y}_t\right) \tag{87}$$

where λ_{it} is the multiplier on the promise-keeping constraint and ϕ_{it} is the multiplier on the participation constraint. Thus

$$-\frac{\partial u_N(\mathbf{u}_{t+1}, a_{t+1}, \boldsymbol{y}_t)}{\partial u_{i,t+1}(y_{irt})} = \frac{\eta\left(\boldsymbol{y}_t\right)}{\lambda_{it} + \phi_{it}\left(\boldsymbol{y}_t\right)} \tag{88}$$

and changes to time t consumption arising from a change in any components of time t income, $x^k_{i,t}$ will be proportional to the corresponding change in the time $t+1$ promise.

Under moral hazard, inverse marginal utility, through transfers, is determined according to

FOC for transfers, equation (45):

$$\lambda_{it} + \varphi_{it} h_i(\mathbf{y}_t, \mathbf{y}_{t-1}) + \psi^1_{it} r^1_i(\mathbf{y}_t, \mathbf{y}_{t-1}) + \psi^2_{it} r^2_i(\mathbf{y}_t, \mathbf{y}_{t-1}) = \frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} \tag{89}$$

and the future promise according to to FOC for $u_{i,t+1}$, equation (39), which can be rearranged as:

$$\lambda_{it} + \varphi_{it} h_i(\mathbf{y}_t, \mathbf{y}_{t-1}) + \psi^1_{it} r^1_i(\mathbf{y}_t, \mathbf{y}_{t-1}) + \psi^2_{it} r^2_i(\mathbf{y}_t, \mathbf{y}_{t-1}) = -\frac{\partial u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_t(\mathbf{y}_t), \mathbf{y}_t)}{\partial u_{i,t+1}(\boldsymbol{y}_t)} \tag{90}$$

where again λ_{it} is the multiplier on the promise-keeping constraint, φ_{it} is the multiplier on the incentive-compatibility constraint, and ψ^1_{it} and ψ^2_{it} are the multipliers on the two threat-keeping constraints. So again,

$$-\frac{\partial u_N(\mathbf{u}_{t+1}(\mathbf{y}_t), \hat{\mathbf{u}}_{t+1}(\mathbf{y}_t), a_t(\mathbf{y}_t), \mathbf{y}_t)}{\partial u_{i,t+1}(\boldsymbol{y}_t)} = \frac{\eta_t(\mathbf{y}_t)}{v'(y_{it} + \tau_{it}(\mathbf{y}_t))} \tag{91}$$

and changes to time t consumption arising from a change in any components of time t income, $x^k_{i,t}$ will be proportional to the corresponding change in the time $t+1$ promise.

1 The case of individual heterogeneity

A change in income component x^k, Δx^k_{it}, will affect both transfers and future promised utility through its effects on the promising-keeping constraint multiplier (λ_{it}) and the respective incentive constraint multipliers (ϕ_{it} for limited commitment; $\varphi_{it}, \psi^1_{it}$ and ψ^2_{it} for moral hazard).

Under either limited commitment or moral hazard, the marginal propensity to consume out of income component x^k_{it} at time t is proportional to the marginal propensity to consume out of income component x^j_{it} at time $t+1$, by equations (88) and (91), respectively. Therefore:

$$\begin{aligned} \pi_i^{k,MH} &= \pi_i^{j,MH} \\ \pi_i^{k,LC} &= \pi_i^{j,LC} \end{aligned} \tag{92}$$

because, after an innovation to income, the planner optimally updates the current and future utilities promised to the household proportionally. While the π may vary across households due to individual heterogeneity, the proportionality is common across income innovations.

2 Measurement error in consumption

The true marginal propensity to consume out of x^k is

$$c_{i,t} = \pi^k x_{i,t}^k + \varepsilon_{i,t} \tag{93}$$

The true π is unknown and must be estimated. First consider measurement error in the left-hand side variable: assume true consumption, c, is unobserved and an error-ridden measure, $\tilde{c} = c + v$ is observed. (The x are assumed for now to be observed without error.) The measurement error v may be correlated with c:

$$corr(c_{it}, v_{it}) \neq 0$$

The probability limit of π^k is:

$$p\lim \tilde{\pi}_i^k = \frac{\frac{1}{n}\sum \left(x_{i,t}^k\right)\left(\pi_i^k x_{i,t}^k + \varepsilon_{i,t} - v_{i,t}\right)}{\frac{1}{n}\sum \left(x_{i,t}^k\right)^2} = \pi_i^k \tag{94}$$

When the measurement error is in the left-hand side variable, it is absorbed into the error term, $\varepsilon_{i,t} - v_{i,t}$ (Greene 2003, Section 5.6). Thus, π_i^k is consistently estimated, though the error will exhibit heteroskedasticity when $corr(c_{it}, v_{it}) \neq 0$.

3 Strategic misreporting of income

Does strategic misreporting of income bias tests of the null hypotheses that $\frac{\pi_{1C1}}{\pi_{2C1}} = \frac{\pi_{1L1}}{\pi_{2L1}}$ and $\frac{\pi_{1C1}}{\pi_{2C1}} = \frac{\pi_{1F1}}{\pi_{2F1}}$ (equations 29 and 30)?

For simplicity, group together livestock and fish income as "animal income." Suppose that strategic misreporting of income is present, such that harder-to-verify income (from animals) is reported with more error compared to easier-to-verify income (crops).[41] Specifically, assume that the measured amount of income of type k, $\widetilde{x}_{i,t}^k$ is related to the true value of income of type k, $x_{i,t}^k$ as follows:

$$\widetilde{x}_{i,t}^k = x_{i,t}^k \cdot \eta_{i,t}^k$$

with $\sigma^2_{\eta^{animal}} > \sigma^2_{\eta^{crop}}$. As above, the true marginal propensity to consume out of x^k is given by equation (93). The probability limit of π^k is:

$$p\lim \tilde{\pi}_t^k = \frac{\frac{1}{n}\sum \left(x_{i,t}^k \cdot \eta_{i,t}^k\right)\left(\pi_i^k x_{i,t}^k + \varepsilon_{i,t}\right)}{\frac{1}{n}\sum \left(x_{i,t}^k \cdot \eta_{i,t}^k\right)^2} = \pi_t^k \left(\frac{\sigma^2_{x^k}}{\sigma^2_{x^k} + \sigma^2_{\eta^k}}\right) \tag{95}$$

which is the standard attenuation bias result (Greene 2003, Section 5.6).

Under the null hypothesis, the true ratios are equal: $\frac{\pi_{1Crop1}}{\pi_{2Crop1}} = \frac{\pi_{1Animal1}}{\pi_{2Animal1}}$. Using the estimated ratios, one will estimate

$$\pi_{1Crop1}\left(\frac{\sigma^2_{xCrop}}{\sigma^2_{xCrop}+\sigma^2_{\eta Crop}}\right)/\pi_{2Crop1}\left(\frac{\sigma^2_{xCrop}}{\sigma^2_{xCrop}+\sigma^2_{\eta Crop}}\right)=\frac{\pi_{1Crop1}}{\pi_{2Crop1}} \tag{96}$$

and

$$\pi_{1Animal1}\left(\frac{\sigma^2_{xAnimal}}{\sigma^2_{xAnimal}+\sigma^2_{\eta Animal}}\right)/\pi_{2Animal1}\left(\frac{\sigma^2_{xAnimal}}{\sigma^2_{xAnimal}+\sigma^2_{\eta Animal}}\right)=\frac{\pi_{1Animal1}}{\pi_{2Animal1}} \tag{97}$$

Since, under the null, $\frac{\pi_{1Crop1}}{\pi_{2Crop1}}=\frac{\pi_{1Animal1}}{\pi_{2Animal1}}$, the expectations of equations (97) and (96) will be equal. Thus, strategic misreporting of income does not bias tests of the null hypothesis.

■

Proposition 7 *Classical measurement error biases OLS results toward a rejection of mean-sufficiency of LIMU; instrumenting lagged consumption yields consistent estimates.*

Proof: Note that we want to estimate the part of consumption that is unexplained by LIMU and village-year effect:

$$\varepsilon_{ivt}=\ln c_{ivt}-\delta_{vt}-\gamma\ln c_{iv,t-1} \tag{98}$$

Assume an error-ridden measure of consumption is observed,

$$\tilde{c}_{iv,t-1}=c_{iv,t-1}\cdot\nu_{iv,t-1}$$

where the measurement error $\nu_{iv,t-1}$ is uncorrelated with true time $t-1$ consumption, $c_{iv,t-1}$, or true time t consumption, c_{ivt}. The estimated prediction error is constructed using observed lagged consumption $\tilde{c}_{iv,t-1}$, and the estimates of γ and δ:

$$\hat{\varepsilon}_{ivt}=\ln c_{ivt}-\hat{\delta}_{vt}-\hat{\gamma}\ln\tilde{c}_{iv,t-1}$$

Assume the true data-generating process is a model with sufficiency of LIMU, such as insurance constrained by limited commitment or moral hazard. Then, the forecast error (98) will be uncorrelated with lagged income:

$$\mathbb{E}\underbrace{(\ln c_{ivt}-\gamma\ln c_{iv,t-1}-\delta_{vt})}_{\text{“true” residual }\varepsilon_{ivt}}y_{iv,t-1}=0 \tag{99}$$

However, if γ is estimated by OLS, the null hypothesis (99) may potentially be incorrectly rejected, because $\hat{\gamma}$ is biased downward:

$$p\lim \hat{\gamma} = \gamma \left(1 - \frac{\sigma_\nu^2}{\sigma_c^2 + \sigma_\nu^2}\right)$$

The estimated residual is then positively correlated with lagged income, because fraction $\frac{\sigma_\nu^2}{\sigma_c^2+\sigma_\nu^2}$ of current log consumption is incorrectly not projected onto lagged log consumption, and this term is correlated with lagged income (because under either limited commitment or moral hazard, contemporaneous income and consumption are positively correlated):

$$\begin{aligned} \hat{\varepsilon}_{ivt} &= \ln c_{ivt} - \hat{\delta}_{vt} - \hat{\gamma} \ln \tilde{c}_{iv,t-1} \\ p\lim \hat{\varepsilon}_{ivt} &= \ln c_{ivt} - \hat{\delta}_{vt} - \gamma \left(1 - \frac{\sigma_\nu^2}{\sigma_c^2 + \sigma_\nu^2}\right) \ln \tilde{c}_{iv,t-1} \\ &= \underbrace{\ln c_{ivt} - \hat{\delta}_{vt} - \gamma \ln \tilde{c}_{iv,t-1}}_{\text{uncorrelated w/ } y_{iv,t-1}} + \underbrace{\frac{\sigma_\nu^2}{\sigma_c^2 + \sigma_\nu^2} \gamma \ln \tilde{c}_{iv,t-1}}_{\text{+ correlated w/ } y_{iv,t-1}} \end{aligned}$$

That is, we may conclude wrongly that $corr(\hat{\varepsilon}_{ivt}, y_{iv,t-1}) > 0$, that is, that LIMU is not sufficient to predict current inverse marginal utility when consumption is measured with classical error, because lagged income is then in effect a second proxy for true LIMU.

However, for classical error, there is a straightforward solution. If γ is estimated using the second lag of consumption as an instrument for the first lag, we obtain a consistent estimate of γ:

$$\begin{aligned} p\lim \hat{\gamma}^{IV} &= \frac{cov(\ln \tilde{c}_{iv,t-2}, \ln \tilde{c}_{ivt})}{cov(\ln \tilde{c}_{iv,t-2}, \ln \tilde{c}_{iv,t-1})} \\ &= \gamma \left(1 - \underbrace{\frac{cov(\nu_{t-2}, \nu_{t-1})}{cov(\ln \tilde{c}_{iv,t-2}, \ln \tilde{c}_{iv,t-1})}}_{=0}\right) \end{aligned}$$

Then, the probability limit of the residual is

$$\begin{aligned} p\lim \hat{\varepsilon}_{ivt}^{IV} &= \ln \tilde{c}_{ivt} - \hat{\delta}_{vt} - \gamma \ln \tilde{c}_{iv,t-1} \\ &= \ln c_{ivt} + \ln \nu_{ivt} - \hat{\delta}_{vt} - \gamma \left(\ln c_{iv,t-1} + \ln \nu_{iv,t-1}\right) \end{aligned}$$

Rearranging,

$$p\lim \hat{\varepsilon}_{ivt}^{IV} = \underbrace{\ln c_{ivt} - \gamma \ln c_{iv,t-1} - \delta_{vt}}_{\text{“true” residual}} + \underbrace{\ln \nu_{ivt}}_{\text{meas. error in } c_{ivt}} - \gamma \underbrace{\ln \nu_{iv,t-1}}_{\text{meas. error in } c_{iv,t-1}}$$

Under the hypothesis that true lagged inverse marginal utility ($\ln c_{iv,t-1}$) is sufficient to predict true current inverse marginal utility, the "true" residual (98) is uncorrelated with lagged income. Moreover, if the measurement error in (log) consumption is classical, $\ln \nu_{ivt}$ and $\ln \nu_{iv,t-1}$ are also uncorrelated with lagged income:

$$corr(\ln \nu_{ivt}, y_{iv,t-1}) = corr(\ln \nu_{iv,t-1}, y_{iv,t-1}) = 0$$

Therefore, with classical measurement error and a true data-generating process of limited commitment or moral hazard, instrumenting the first lag of consumption with the second lag of consumption will lead to the correct conclusion:$p \lim \hat{\varepsilon}_{ivt}^{IV} y_{iv,t-1} = 0$.■

B Appendix: Amnesia

A stronger implication of limited commitment, which does not hold under moral hazard or borrowing-saving, is what Kocherlakota (1996) calls "amnesia." When limited commitment binds for household i, consumption c_{irt} and promised future utility $u_{ir,t+1}$ are pinned down by the requirement that the household be just indifferent between staying in and leaving the network, and that the utility value of current and future consumption be equated at the margin:

$$v(y_r + \tau_{irt}) + \beta u_{ir,t+1} = u^t_{aut}(y_r)$$

$$v'(y_r + \tau_{irt}) = -\left(\frac{\partial u_N(\mathbf{u}_{r,t+1})}{\partial u_{ir,t+1}}\right)^{-1}$$

independent of the time t promised value u_{it}. Thus the household's old promised value, u_{it}, is "forgotten" when limited commitment binds. Kocherlakota suggests the following procedure to test for amnesia: find the network member(s) with the lowest growth in consumption between periods $t-1$ and t. Define

$$B_t \equiv \min_{i=1,\ldots,N} v'(c_{i,t-1})/v'(c_{it})$$

Those for whom $v'(c_{i,t-1})/v'(c_{it}) > B_t$, by construction, had binding limited commitment constraints—otherwise their consumption would have been fully smoothed between periods $t-1$ and t. Those with $v'(c_{i,t-1})/v'(c_{it}) = B_t$ were not constrained, and therefore did achieve full intertemporal consumption smoothing. Define the sets of constrained and unconstrained households

$$C_t \equiv \{i : v'(c_{i,t-1})/v'(c_{it}) > B_t\}$$
$$U_t \equiv \{i : v'(c_{i,t-1})/v'(c_{it}) = B_t\}$$

Amnesia implies that, for any constrained household $i \in C_t$, LIMU $\left(\frac{1}{v'(c_{i,t-1})}\right)$ should not predict current consumption c_{it}, given current income y_{jt}. That is, if we estimate the regression

$$\ln c_{it} = \alpha_1 \ln c_{i,t-1} + \alpha_2 \ln y_{it} + \delta_v + \varepsilon_{it} \qquad (100)$$

for those households $i \in C_t$, limited commitment implies, since the households are constrained, $\alpha_1 = 0$: the old promises are forgotten.

A Testing amnesia

Appendix Table B1 presents tests of the amnesia prediction of the limited commitment model. If there is measurement error in expenditure, exactly following Kocherlakota's proposed procedure for implementing this test—classifying as constrained every household in a village who had consumption growth above the village minimum—would result in every household but one in each village appearing constrained. In fact, many of these households will be unconstrained, and including them in the set of households for whom amnesia is predicted will introduce bias toward rejecting the predictions of limited commitment. To address this, interaction terms between $\ln \frac{1}{v'(c_{i,t-1})}$ and indicators for the quartile of the village distribution of consumption growth between $t-1$ and t into which the household fell ($\mathbf{1}_q$); and similar interaction terms with $\ln(y_{i,t})$ are added to (100). That is, estimate

$$\ln c_{it} = \alpha + \beta_1 \ln c_{i,t-1} + \sum_{q=2}^{4} \beta_q \ln c_{i,t-1} \times \mathbf{1}_q + \gamma_1 \ln y_{it} + \sum_{q=2}^{4} \gamma_q \ln y_{i,t} \times \mathbf{1}_q + \delta_{vt} + \varepsilon_{it}$$

If past promises are forgotten, conditional on current income, for those who had highest consumption growth due to binding participation constraints, the sum of the coefficients on the LIMU terms $\beta_1 + \beta_q$ should be low and insignificant for higher quartiles of consumption growth and, since the main effect of $\ln \frac{1}{v'(c_{i,t-1})}$ is positive and significant, β_4 should be negative. In fact, these predictions are rejected. Column 1 presents the results. The pattern of coefficients β_q is the opposite of that predicted by amnesia—LIMU is *more* strongly (positively), predictive of current consumption, conditional on current income, for households with higher consumption growth: β_4 is larger than β_3, which in turn is larger than β_2. For those in the highest quartile of consumption growth, the hypothesis that $\beta_1 + \beta_4$ equals zero is overwhelmingly rejected, suggesting again that limited commitment is not the (entire) explanation for incomplete insurance in these villages. Column 2 shows that allowing the effect of past income to also vary by quartile of conumption growth does not change the finding that amnesia is rejected. The result is also unchanged when the top and bottom 5% (columns 3 and 4) or 10% (columns 5 and 6) of per capita expenditure by year are dropped, to address the concern that very high or low observed consumption may be due to measurement error.

Appendix table B1: Testing amnesia

	(1)	(2)	(3)	(4)	(5)	(6)
	Full Sample	Full Sample	Drop 10%	Drop 10%	Drop 20%	Drop 20%
LIMU	0.7270***	0.6150***	0.6526***	0.5495***	0.5843***	0.4985***
	(0.0107)	(0.0161)	(0.0111)	(0.0168)	(0.0118)	(0.0155)
LIMUX25	0.0522***	0.1715***	0.0438***	0.1638***	0.0378***	0.1440***
	(0.0015)	(0.0171)	(0.0014)	(0.0175)	(0.0013)	(0.0156)
LIMUX50	0.0841***	0.2227***	0.0726***	0.2075***	0.0643***	0.1861***
	(0.0015)	(0.0171)	(0.0014)	(0.0171)	(0.0013)	(0.0161)
LIMUX75	0.1382***	0.1241***	0.1176***	0.1473***	0.1030***	0.1258***
	(0.0019)	(0.0261)	(0.0016)	(0.0202)	(0.0016)	(0.0196)
ln(inc)		0.1603***		0.1444***		0.1243***
		(0.0139)		(0.0139)		(0.0127)
ln(inc)X25		-0.1115***		-0.1117***		-0.0983***
		(0.0154)		(0.0158)		(0.0140)
ln(inc)X50		-0.1284***		-0.1245***		-0.1116***
		(0.0154)		(0.0154)		(0.0145)
ln(inc)X75		0.0016		-0.0342*		-0.0264
		(0.0231)		(0.0179)		(0.0172)
Constant	1.9453***	1.3374***	2.7708***	2.2446***	3.5098***	3.0231***
	(0.1026)	(0.0906)	(0.1088)	(0.1043)	(0.1183)	(0.1156)
Observations	6,924	6,838	6,244	6,161	5,550	5,473
R-squared	0.7644	0.7838	0.7025	0.7219	0.6322	0.6532
Fixed Effects	Village	Village	Village	Village	Village	Village
Sample	Full	Full	Middle 90	Middle 90	Middle 80	Middle 80

Notes: LIMU is lagged inverse marginal utility.

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

C Appendix: Additional Tables

A Linearized tests of hidden income: insufficiency of LIMU and predictive power of lagged income

Under either limited commitment or moral hazard, all past information relevant to forecasting current inverse marginal utility is encoded in last period's inverse marginal utility and a village-year fixed effect. Thus:

$$\mathbb{E}_{t-1}\left[\frac{1}{v'(c_{it})}\right] = f\left(\frac{1}{v'(c_{it})}, \eta_t\right) \tag{101}$$

If (101) holds, the prediction errors:

$$\hat{\varepsilon}^*_{it} \equiv \frac{1}{v'(c_{it})} - \mathbb{E}\left(\frac{1}{v'(c_{it})} | \frac{1}{v'(c_{i,t-1})}, \eta_t\right) \tag{102}$$

should be uncorrelated with past income, a finding that contrasts with the prediction of the hidden income model. Under Lemma 4, prediction errors from forecasting current inverse marginal utility based on LIMU will be positively correlated with income in the previous period.

Table A4 tests this implication. Consistent with the hidden income prediction, when the prediction errors defined in equation (102) are regressed on lagged income (and lagged income and lagged income squared interacted with the aggregate shock measure η_t) the slope is positive and significant while the intercept is significantly negative (column 1). Since the dependent variable is a regression residual, which has mean zero by construction, the slope and intercept are not independent. The joint hypothesis that $\alpha = 0, \beta = 0$ is rejected at the $.0001$ level. Column 2 shows that instrumenting $\ln c_{iv,t-1}$ with $\ln c_{iv,t-2}$ does not overturn the finding that the prediction residuals are negative at low levels of lagged income: the null that the slope and the intercept in (102) are both 0 is rejected at the 1% level. This suggests that the rejection of sufficiency of LIMU is not driven by classical measurement error.

Table C1: Summary statistics

		531-HH panel mean	Non-continuously observed HH difference	N
	Monthly income	8981.224	-2624.627	670
	Monthly expenditure	5213.472	-1108.721***	670
	Monthly income, resids	32.443	-163.756	670
	Monthly expenditure, resids	67.416	-570.84	670
	Household size	4.525	-0.663***	669
	Adult equivalents	3.786	-0.638***	669
	Adult men	1.382	-0.324***	669
	Adult women	1.552	-0.247***	669
Gifts given:	Gifts to orgs in village	33.714	-9.813	670
	Gifts to orgs not in village	53.749	-29.063**	670
	Gifts given for events in village	103.219	-35.550***	670
	Gifts given for events not in village	220.117	-140.576***	670
	Other gifts to HHs in village	147.317	-29.854	670
	Other gifts to HHs not in village	637.198	-96.868	670
Gifts received:	Gifts from orgs in village	36.105	-20.002**	670
	Gifts from orgs not in village	38.963	10.82	670
	Gifts rec'd for events in village	316.862	-213.653***	670
	Gifts rec'd for events not in village	80.068	9.976	670
	Other gifts from HHs in village	118.129	-20.575	670
	Other gifts from HHs not in village	1327.131	-253.376	670
Occupation (household head, baseline)				
	Rice farmer	0.355	0.116*	667
	Non-ag labor	0.119	0.033	667
	Corn farmer	0.098	-0.062*	667
	Livestock farmer	0.089	-0.082***	667
	Ag wage labor	0.051	0.007	667
	Other crop farmer	0.043	-0.036*	667
	Shrimp/fish farmer	0.036	-0.021	667
	Orchard farmer	0.017	0.005	667
	Construction	0.015	0.036*	667
	Other	0.074	0.013	667

Notes: All baht-denominated variables were converted to 2002 baht using the Thai Ministry of Trade's Rural Consumer Price Index for Thailand. In 2002, approximately 42 Thai baht were equal to US$1. Income and expenditure resids are residuals from regression on village, year, occupation and demographic variables.

Table C2: Testing the hidden income model, full sample

	(1)	(2)	(3)
Lagged consumption	0.290		
	(0.0440)		
Lagged IHS income	40.15	23.09	18.93
	(6.703)	(6.326)	(6.284)
Village-month fixed effect?	Yes	Yes	Yes
Village-month fixed effect $\times c_{t-1}$?	Yes	Yes	Yes
Estimation method	OLS	OLS	OLS
R-squared	0.102	0.369	0.380
Observations	44,073	44,073	44,073

Notes: Sample includes household-month observations with negative lagged net income. Standard errors clustered at the village quarter level in brackets. IHS is inverse hyperbolic sine (see text).
Model 1: $\rho = 1$, including village-month fixed effects (η'_{-it}) and $\eta'_{-it} \times c_{t-1}$.
Model 2: $\rho = 1$, including village-month fixed effects (η'_{-it}) and $\eta'_{-it} \times c_{t-1}$ and quadratic splines in lagged consumption.
Model 3: $\rho = 1$, including quadratic splines in estimated village-month effects (η'_{-it}) and quadratic splines in lagged consumption and lagged consumption$\times \eta'_{-it}$.

Table C3: Predicting income with rainfall

Occupation	R^2	N
Rice farmer	0.386	752
Construction	0.292	32
Orchard farmer	0.222	36
Shrimp/fish farmer	0.195	76
Agricultural wage labor	0.143	108
Livestock	0.142	188
Other crop farmer	0.120	92
Non-agricultural wage labor	0.116	252
Other	0.100	156
Corn farmer	0.088	208

Notes: R^2 is the R-squared of annual income on quarterly income deviations and squared deviations, plus province-fixed effects. N is the number of household-year observations.

Table C4: Testing the hidden income model (CRRA utility, linear estimates)

LHS=Prediction residuals from a regression of $ln(c_t)$ on $ln(c_{t-1})$ and a village-year effect

	OLS	IV
	(1)	(2)
Constant (α)	-.4839	-.2123
	[.0694]	[.0576]
Lagged log income (β)	.0453	.0205
	[.0063]	[.0052]
Chi-square stat (α<0, β>0)	54.84	19.40
p value	(0.000)	(0.000)
Observations	2781	2322

Notes: Bootstrapped standard errors in brackets. Regressions include a village-year fixed effect. Chi-square stat is the statistic for the test that the slope$>$0, intercept$<$0. P-value in brackets.