Risk Sharing with Limited Commitment and Preference Heterogeneity: Structural Estimation and Testing

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Appendices

A Computation

This appendix details how to compute the state-dependent optimal intervals on the relative Pareto weight of each household. Consider household i sharing risk with v. Take σ_i, σ, δ, φ, and the income processes F_{Y_i} and F_{Y_v} as given.

Define a grid over the continuous variable x_i. The limits of the grid are given by the minimum and maximum values for the ratio of marginal utilities given the possible income realizations. I define an equidistant grid on $\log(x_i)$ of 200 points. Guess initial values for the value functions, that is, guess $V_i^0(s, x_i)$ and $V_v^0(s, x_i)$, for each s and grid point. I use the value function of perfect risk sharing as the initial guess.[1]

Then proceed to update the guess. Suppose we are at iteration h. For each income state s, one can directly find the limits of the 'optimal' intervals at iteration h, denoted $\underline{x}_i^h(s)$ and $\overline{x}_i^h(s)$. To compute $\underline{x}_i^h(s)$, I use the participation constraint of household i with equality, i.e.,

$$u_i\left(c_i^h(s)\right) + \delta \sum_{s'} \pi\left(s' \mid s\right) V_i^{h-1}\left(s', x_i'\right) = U_i^{aut}(s), \tag{1}$$

the optimality condition

$$\frac{u_v'\left(c_v^h(s)\right)}{u_i'\left(c_i^h(s)\right)} = \underline{x}_i^h(s),$$

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[1]It is clear that the algorithm does not converge to the constrained-efficient solution from any initial guess for the value functions. For example, if one sets $V_i^0(s, x_i)$ and $V_v^0(s, x_i)$ equal to the autarky values, every iteration yields these same autarky values. This is natural, since autarky is also a subgame perfect Nash equilibrium (SPNE).

and the resource constraint. Similarly, to find $\overline{x}_i^h(s)$, I use

$$u_v\left(c_v^h(s)\right)+\delta\sum_{s'}\pi\left(s'\mid s\right)V_v^{h-1}\left(s',x_i'\right)=U_v^{aut}\left(s\right), \tag{2}$$

the optimality condition

$$\frac{u_v'\left(c_v^h(s)\right)}{u_i'\left(c_i^h(s)\right)}=\overline{x}_i^h(s),$$

and the resource constraint. Note the upper index $(h-1)$ for $V_i()$ and $V_v()$ in equations (1) and (2), respectively, that is, I use the value function from the previous iteration. I do linear interpolation on $V_i^{h-1}()$ and $V_v^{h-1}()$ for values of x_i' not on the grid. Finally, the value functions are updated.

I continue iterating until the value functions converge. As a result, I have the solution in the form $[\underline{x}_i(s),\overline{x}_i(s)]$, $\forall s$.

B Proofs and discussion of identification

Compared to perfect risk sharing, additional information can only come from binding PCs. Hence, let us assume that there exists some state $\tilde{s}$ where household i's PC is binding. One can write the PC as equality as

$$u\left(\left(1-\varphi\right)y_i\left(\tilde{s}\right)\right)-u\left(\underline{c}_i^{\tilde{s}}\right)=\delta\sum_{s}\pi\left(s\mid\tilde{s}\right)\left[V_i\left(s,\underline{x}_i^{\tilde{s}}\right)-U_i^{aut}(s)\right]. \tag{3}$$

I show under which conditions one, two, and three parameters are identified. For simplicity I consider two ex-ante identical households.

Denote by $\overline{\overline{\delta}}$ the discount factor such that $\forall\delta\geq\overline{\overline{\delta}}$ perfect risk sharing is self-enforcing, and by $\underline{\underline{\delta}}$ the discount factor such that $\forall\delta\leq\underline{\underline{\delta}}$ all households stay in autarky.[2] If $\delta=\underline{\underline{\delta}}$, each state-dependent optimal interval is just one point each. If $\delta=\overline{\overline{\delta}}$, there exists $\tilde{x}$ such that the PCs in all states are satisfied, i.e., all the state-dependent intervals overlap. Similarly, for σ sufficiently low, agents are in autarky, and for σ and φ sufficiently high, perfect risk sharing occurs.[3]

Now, it is easy to see that, given σ and φ, $\exists\overline{\delta}$ such that PCs bind in only two income state, i.e., consumption of both households takes two values in the long run, for all δ such that $\overline{\delta}\leq\delta<\overline{\overline{\delta}}$. There also $\exists\underline{\delta}$ such that for all δ such that $\underline{\delta}\leq\delta<\overline{\delta}$, consumption of both households takes four values in the long run. Finally, for all δ such that $\underline{\underline{\delta}}<\delta<\underline{\delta}$,

[2] Ligon et al. (2002) have shown that $\overline{\overline{\delta}}$ and $\underline{\underline{\delta}}$ exist.

[3] For φ sufficiently close to 0, agents may or may not be in autarky, depending on the other parameters of the model.

consumption of both households takes at least six values in the long run and partial insurance occurs. Note that a necessary condition is that each agent's income takes at least four values. These statements follow from the fact that the lower (upper) limits of the optimal intervals, $\underline{x}_i^s$ ($\overline{x}_i^s$), are continuous and decreasing (increasing) in δ. Similar statements can be made for the other two parameters.[4] Note also that the same hold for the state-dependent optimal consumption intervals, denoted $[\underline{c}_i^s, \overline{c}_i^s]$, where ${u'\left(Y^s - \underline{c}_i^s\right)}/{u'\left(\underline{c}_i^s\right)} = \underline{x}_i^s$ and ${u'\left(Y^s - \overline{c}_i^s\right)}/{u'\left(\overline{c}_i^s\right)} = \overline{x}_i^s$, where Y^s is aggregate income in state s.

Proof of Claim 1. If the PC binds in only one income state for each household, in state $\tilde{s}$ for household i and $-\tilde{s}$ for the other household, then the relative Pareto weight takes two values in the long run, and, by symmetry, it takes the values $\underline{x}_i^{\tilde{s}}$ and ${1}/{\underline{x}_i^{\tilde{s}}}$. First, take σ and φ as given. I show that (3) identifies δ. It is easy to see that $U_i^{aut}(s)$ is continuous in δ. Ligon et al. (2002) have shown that the limits of the optimal intervals are continuous in δ. Since $V_i\left(s, \underline{x}_i^{\tilde{s}}\right)$ is a continuous function of the limits of the state-dependent intervals, it is itself continuous in δ. We have to show that the expected future gain of insurance, the right hand side of (3), is strictly increasing in δ, for $\delta \in \left(\overline{\delta}, \overline{\overline{\delta}}\right)$. To see this, denoting the probability of state $\tilde{s}$ (and $-\tilde{s}$) occurring by $\pi^{\tilde{s}}$, rewrite (3) as

$$u\left((1-\varphi)\, y_i(\tilde{s})\right) - u\left(\underline{c}_i^{\tilde{s}}\right) = \frac{\delta}{1-\delta}\left[\left(1 - \frac{\pi^{\tilde{s}}}{1-\delta\left(1-2\pi^{\tilde{s}}\right)}\right) u\left(\underline{c}_i^{\tilde{s}}\right) + \frac{\pi^{\tilde{s}}}{1-\delta\left(1-2\pi^{\tilde{s}}\right)} u\left(\overline{c}_i^{-\tilde{s}}\right) \right.$$
$$\left. - \mathbb{E}u\left((1-\varphi)\, y_i\right)\right]. \tag{4}$$

The derivative of the right hand side of (4) with respect to δ is

$$\frac{1}{(1-\delta)^2}\left[\left(1 - \pi^{\tilde{s}} \frac{1-\delta^2\left(1-2\pi^{\tilde{s}}\right)}{\left(1-\delta\left(1-2\pi^{\tilde{s}}\right)\right)^2}\right) u\left(\underline{c}_i^{\tilde{s}}\right)\right.$$
$$\left. + \pi^{\tilde{s}} \frac{1-\delta^2\left(1-2\pi^{\tilde{s}}\right)}{\left(1-\delta\left(1-2\pi^{\tilde{s}}\right)\right)^2} u\left(\overline{c}_i^{-\tilde{s}}\right) - \mathbb{E}u\left((1-\varphi)\, y_i\right)\right]. \tag{5}$$

Next, I show that the term

$$\overline{\pi} \equiv \pi^{\tilde{s}} \frac{1-\delta^2\left(1-2\pi^{\tilde{s}}\right)}{\left(1-\delta\left(1-2\pi^{\tilde{s}}\right)\right)^2}$$

is between $\pi^{\tilde{s}}$ and $\frac{1}{2}$ for all $0 \leq \delta \leq 1$ and $0 < \pi^{\tilde{s}} \leq \frac{1}{2}$. It is easy to see that $\overline{\pi} = \pi^{\tilde{s}}$ for $\delta = 0$ and that $\overline{\pi} = \frac{1}{2}$ for $\delta = 1$. To see how $\overline{\pi}$ behaves for δ's between these two values, let us take its derivative with respect to δ. This gives

$$\frac{\partial \overline{\pi}}{\partial \delta} = \pi^{\tilde{s}} \frac{2\delta(1-\delta)\left(1-2\pi^{\tilde{s}}\right)^2}{\left(1-\delta\left(1-2\pi^{\tilde{s}}\right)\right)^3} > 0.$$

[4] Intuitively, higher δ, σ, and φ mean that PCs are less stringent, hence monotonicity. Ligon et al. (2002) have shown that the limits are continuous in δ. Continuity in σ and φ can be shown in a similar way.

This means that $\overline{\pi}$ is strictly increasing from $\pi^{\tilde{s}}$ to $\frac{1}{2}$ as δ increases from 0 to 1. Hence, $\pi^{\tilde{s}} \leq \overline{\pi} \leq \frac{1}{2}$, as I wanted to show.

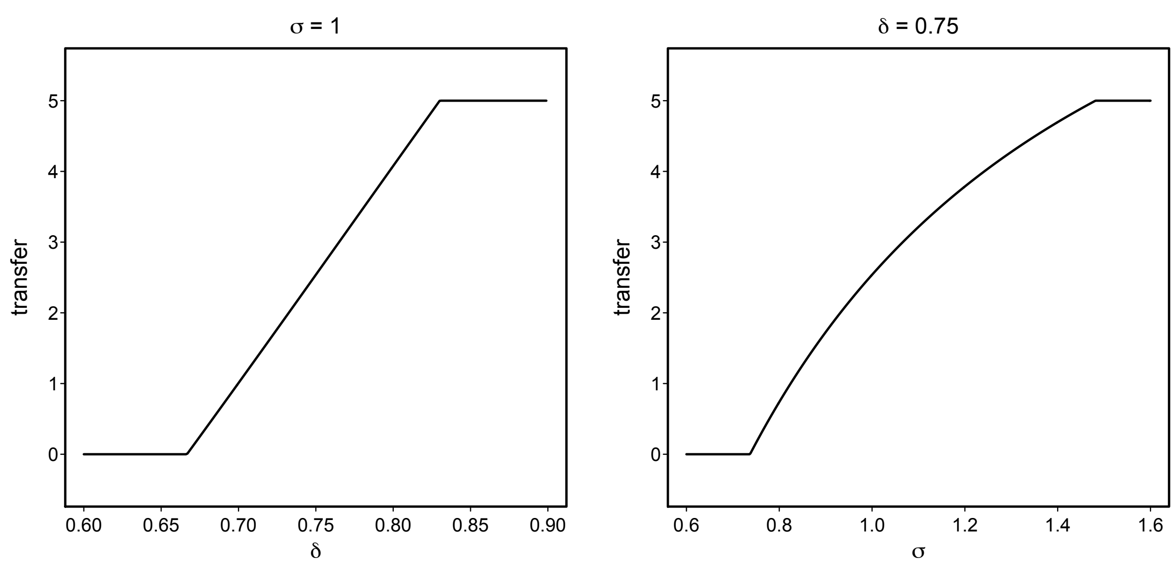
Then,

$$(1-\overline{\pi})\, u\left(\underline{c}_i^{\tilde{s}}\right) + \overline{\pi} u\left(\overline{c}_i^{-\tilde{s}}\right) - \mathbb{E}u\left((1-\varphi)\, y_i\right) \geq \frac{1}{2} u\left(\underline{c}_i^{\tilde{s}}\right) + \frac{1}{2} u\left(\overline{c}_i^{-\tilde{s}}\right) - \mathbb{E}u\left((1-\varphi)\, y_i\right) > 0,$$

where the second inequality holds because whenever partial risk sharing occurs, the long-run per-period utility of risk sharing must be higher than the long-run per-period utility of autarky. Hence, the derivative (5) is positive. It follows that one binding PC identifies δ. In fact, fixing any two parameters, the third can be computed using (4) as long as partial risk sharing occurs. □

Claim 1 suggests that each of the three parameters plays the same role here: each captures how much risk sharing occurs. To illustrate this, consider the following income process: both households earn 20 or 10 with equal probabilities each period, and there is no aggregate risk. Figure A1 shows this for δ and σ. In the first panel, I set $\sigma = 1$ and vary δ. In the second panel, I set $\delta = 0.75$ and vary σ. Any transfer/consumption level observed can be matched by varying either δ or σ.

Figure A1: The transfer from the household who gets 20 to the household who gets 10, $\varphi = 0$.



Proof of Claim 2. If PCs bind in two income states for each houshold, then consumption of each household takes four values in the long run. Let $\overline{y}$ denote average income. Consider the income process $y^h = \overline{y} + a$, $y^m = \overline{y}$, $y^l = \overline{y} - a$, with $0 < a < \overline{y}$, and with probabilities $(1-\alpha)/2$, α, and $(1-\alpha)/2$, respectively. Assume that the three state-dependent intervals are disjunct. Denote the consumption values by $\overline{y}+a_1^*>\overline{y}+a_2^*>\overline{y}-a_2^*>\overline{y}-a_1^*$, with $a_1^*<a$. Some tedious algebra leads to the following two-equation system, which gives σ and δ:

$$\delta=\frac{2}{1-\alpha}\frac{u\left((1-\varphi)\overline{y}\right)-u\left(\overline{y}-a_2^*\right)}{u\left((1-\varphi)\overline{y}\right)-u\left(\overline{y}-a_2^*\right)+u\left(\overline{y}-a_1^*\right)-u\left((1-\varphi)\left(\overline{y}-a\right)\right)} \tag{6}$$

$$\delta=\frac{1}{\alpha}\frac{u\left((1-\varphi)\left(\overline{y}+a\right)\right)-u\left(\overline{y}+a_1^*\right)-u\left((1-\varphi)\overline{y}\right)+u\left(\overline{y}-a_2^*\right)}{u\left((1-\varphi)\left(\overline{y}+a\right)\right)-u\left(\overline{y}+a_1^*\right)-u\left((1-\varphi)\overline{y}\right)+u\left(\overline{y}+a_2^*\right)}. \tag{7}$$

First, take φ as given, and, without loss of generality, set $\varphi=0$. The right hand side of (6) is strictly increasing in σ, because $\frac{u(\overline{y}-a_1^*)-u(\overline{y}-a)}{u(\overline{y})-u(\overline{y}-a_2^*)}$ is greater for $u()$ more concave. The right hand side of (7) is strictly decreasing in σ, which can be seen by rewriting it as

$$\frac{1}{1-\frac{1}{-\frac{u(\overline{y}+a)-u(\overline{y}+a_1^*)}{u(\overline{y}+a_2^*)-u(\overline{y}-a_2^*)}+\frac{u(\overline{y})-u(\overline{y}-a_2^*)}{u(\overline{y}+a_2^*)-u(\overline{y}-a_2^*)}}}$$

and again doing comparative statics with respect to the concavity of $u()$. It is clear that both are continuous in σ. Hence, the solution is unique. Then, it is also easy to see that the right hand side of (6) is decreasing, the right hand side of (7) is increasing, and both are continuous in φ. Hence, similarly, fixing σ, a unique combination of δ and φ solve (6) and (7). Also, fixing δ, a unique combination of σ and φ solve (6) and (7). $\square$

Finally, if there are four income states and PCs bind in three income states for each household, then consumption of each household takes six values in the long run. Consider the income process $y^h=\overline{y}+a_1$, $y^{mh}=\overline{y}+a_2$, $y^{ml}=\overline{y}-a_2$, $y^l=\overline{y}-a_1$, with $0<a_2<a_1<1$, and with probabilities α_1, α_2, α_2, and α_1, respectively. All four state-dependent intervals must be disjunct, except the ones relating to the two states where inequality is low. Denote the consumption values by $\overline{y}+a_1^*>\overline{y}+a_2^*>\overline{y}+a_3^*>\overline{y}-a_3^*>\overline{y}-a_2^*>\overline{y}-a_1^*$. When all intervals are disjunct, some tedious algebra leads to the following three-equation system, which gives σ, δ, and φ:

$$u\left(\overline{y}+a_3^*\right)+\frac{\alpha_2}{1-\alpha_2\delta}u\left(\overline{y}-a_3^*\right)-\frac{1}{1-\alpha_2\delta}u\left(\overline{y}-a_2^*\right)=u\left((1-\varphi)\left(\overline{y}+a_2\right)\right)-u\left((1-\varphi)\left(\overline{y}-a_2\right)\right)$$

$$u\left(\overline{y}+a_1^*\right)+\frac{\alpha_2\delta}{1-\alpha_2\delta}u\left(\overline{y}+a_2^*\right)-\frac{1-\alpha_2\delta}{1-2\alpha_2\delta}u\left(\overline{y}+a_3^*\right)=u\left((1-\varphi)\left(\overline{y}+a_1\right)\right)-u\left((1-\varphi)\left(\overline{y}+a_2\right)\right)$$

$$\begin{aligned}&(1-\delta+\alpha_1)\,u\left(\overline{y}+a_1^*\right)+\frac{\alpha_2\left(1-\delta+\alpha_1\delta\right)}{1-\alpha_2\delta}u\left(\overline{y}+a_2^*\right)+\frac{\alpha_1\alpha_2\delta}{\left(1-\alpha_2\delta\right)\left(1-2\alpha_2\delta\right)}u\left(\overline{y}+a_3^*\right)\\&+\frac{\alpha_2\left(1-\delta\right)}{1-2\alpha_2\delta}u\left(\overline{y}-a_3^*\right)+\frac{\alpha_1\alpha_2\delta}{1-\alpha_2\delta}u\left(\overline{y}-a_2^*\right)+\alpha_1 u\left(\overline{y}-a_1^*\right)\\&=(1-\delta+\alpha_1)\,u\left((1-\varphi)\left(\overline{y}+a_1\right)\right)+\alpha_2 u\left((1-\varphi)\left(\overline{y}+a_2\right)\right)\\&\quad+\alpha_2 u\left((1-\varphi)\left(\overline{y}-a_2\right)\right)+\alpha_1 u\left((1-\varphi)\left(\overline{y}-a_1\right)\right).\end{aligned}$$

One gets a similar system when the intervals for the two less unequal states overlap.

C Estimation of income processes

This appendix details how I estimate households' income processes. I allow for heterogeneity in households' income processes. This is important so that transfers predicted by the model be for insurance reasons and not due to permanent income differences across households. It is clear that estimating an AR(1) process for each household using just the six data points available per household would give very imprecise estimates. Instead, I create four groups in each village based on whether a household's mean income and the coefficient of variation of its income is above or below the median.

For each of the four groups in each village, I assume that each household's income follows a common AR(1) process. I estimate

$$y_{it} = (1-\rho)\mu + \rho y_{i,t-1} + \xi_{it}.$$

The parameters are pinned down by the following moments:

$$\begin{aligned} \mu &= \mathbb{E}\left(y_{it}\right) \\ \rho &= Cor\left(y_{it}, y_{i,t-1}\right) \\ \sigma_\xi^2 &= \left(1-\rho^2\right) Var\left(y_{it}\right). \end{aligned}$$

Table A1 shows the estimated parameters.

Table A1: Estimated parameters for the income processes of four groups of households in each village

	Low mean, low risk	Low mean, high risk	High mean, low risk	High mean, high risk
		Aurepalle		
μ	182.475	160.201	441.843	391.798
ρ	0.189	0.626	0.550	0.365
σ_ξ^2	49.088	68.506	128.741	188.458
		Kanzara		
μ	235.906	243.872	506.555	525.520
ρ	0.491	0.285	0.846	0.520
σ_ξ^2	45.808	79.112	122.302	237.918
		Shirapur		
μ	263.292	288.625	446.590	642.628
ρ	0.318	0.000	0.160	0.199
σ_ξ^2	78.793	128.445	129.785	271.997

I then discretize the estimated AR(1) processes. I choose the support points for the Markov chain, ν_j, $j \in \{1, ..., n\}$, as quantiles of the empirical distribution, following Kennan (2006).

I then apply Tauchen (1986)'s method to compute the transition matrix. Let p_{jk} denote the transition probability from ν_j to ν_k. The p_{jk}s are computed as follows:

$$p_{jk} = \begin{cases} \Phi\left(\frac{\nu_1+(\nu_2-\nu_1)/2-(1-\rho)\mu-\rho\nu_j}{\sigma_\xi}\right) & \text{for } k=1, \\ \Phi\left(\frac{\nu_k+(\nu_{k+1}-\nu_k)/2-(1-\rho)\mu-\rho\nu_j}{\sigma_\xi}\right) - \Phi\left(\frac{\nu_k-(\nu_k-\nu_{k-1})/2-(1-\rho)\mu-\rho\nu_j}{\sigma_\xi}\right) & \text{for } 1<k<n, \\ 1-\Phi\left(\frac{\nu_n-(\nu_n-\nu_{n-1})/2-(1-\rho)\mu-\rho\nu_j}{\sigma_\xi}\right) & \text{for } k=n, \end{cases}$$

where $\Phi()$ is the cumulative distribution function of the standard normal distribution. Note that Tauchen assumes that conditional on the previous period's income current income is normally distributed.

To find a Markov chain approximation for mean income in the village, I simulate the household processes over 1000 periods assuming that they are independent, compute mean income in each period (excluding the first 100), and then perform the same steps as for household income.

D Robustness checks

Table A2 shows the estimation and model selection results ignoring measurement error in the previous period's consumption and in current income, and without unobserved heterogeneity in the curvature of the utility function, as in the main text. The second robustness check then allows for measurement errors, as in the main text, and adds an unobservable term to the coefficient of RRA of each household. Table A3 shows the estimation results where the variance of the unobserved heterogeneity term, γ_σ^2, equals 0.02. Parameter estimates do not vary much, and pairwise model comparisons using Vuong (1989)'s test yield the same conclusions as for the baseline models. An interesting further robustness check would be to estimate γ_σ^2 as well. However, attempting this resulted in numerical problems such as unstable estimates and γ_σ^2 and the observed heterogeneity parameters hitting different bounds.

Table A2: Structural estimation and model selection results without measurement error in income and last period's consumption

	Aurepalle				Kanzara				Shirapur			
	LC^{u_i}	LC^{u}	PRS^{u_i}	PRS^{u}	LC^{u_i}	LC^{u}	PRS^{u_i}	PRS^{u}	LC^{u_i}	LC^{u}	PRS^{u_i}	PRS^{u}
δ (discount	0.925***	0.973***			0.933***	0.786***			0.916***	0.887***		
factor)	(0.000)	(0.000)			(0.000)	(0.000)			(0.000)	(0.000)		
φ (punishment	0.358***	0.351***			0.051***	0.317***			0.137***	0.014***		
parameter)	(0.001)	(0.001)			(0.000)	(0.000)			(0.000)	(0.000)		
σ (average coef.	1.078***	3.214***			0.922***	1.572***			1.134***	3.055***		
of RRA)	(0.002)	(0.000)			(0.000)	(0.000)			(0.323)	(0.000)		
β_1/σ (education)	0.019***		0.424***		0.157***		0.118***		0.534***		0.193***	
	(0.001)		(0.027)		(0.000)		(0.022)		(0.004)		(0.022)	
β_2/σ (proportion	1.309***		-0.113		-1.482***		-0.717***		3.087***		1.839***	
of women)	(0.223)		(0.107)		(0.000)		(0.142)		(0.000)		(0.110)	
β_3/σ (age)	-0.037***		-0.003		0.018***		0.040***		-0.044***		-0.030***	
	(0.000)		(0.002)		(0.001)		(0.003)		(0.003)		(0.003)	
β_4/σ (land)	-0.168***		-0.018		-0.509***		-0.146***		-0.646***		0.024**	
	(0.001)		(0.058)		(0.000)		(0.022)		(0.000)		(0.012)	
γ_c^2 (variance of	0.067***	0.065***	0.094***	0.072***	0.068***	0.072***	0.080***	0.075***	0.078***	0.091***	0.100***	0.097***
cons. m.e.)	(0.009)	(0.009)	(0.004)	(0.008)	(0.016)	(0.020)	(0.006)	(0.013)	(0.014)	(0.017)	(0.008)	(0.012)
Log likelihood	21.078	-6.827	0.121	-14.795	23.895	-16.640	-0.287	-20.398	42.808	-31.421	-8.037	-36.679
# of obs.	170	170	170	170	185	185	185	185	155	155	155	155
# of hholds	34	34	34	34	37	37	37	37	31	31	31	31
	Vuong's test – $H_{\text{alt.}}$: model of column is closer to the true data generating process than model of row											
LC^{u}	55.810***		13.896***		81.070***		32.706***		148.457***		46.769***	
	(0.000)		(0.000)		(0.000)		(0.008)		(0.000)		(0.000)	
PRS^{u_i}	41.914***				48.363***				101.689***			
	(0.000)				(0.001)				(0.000)			
PRS^{u}	71.745***	15.935***	29.831***		88.586***	7.517***	40.223***		158.973***	10.516***	57.284***	
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	

Notes: See Table 2.

Table A3: Structural estimation results with measurement errors and unobservable heterogeneity in the curvature of the utility function, $\gamma_\sigma = 0.02$

	Aurepalle		Kanzara		Shirapur	
	LC^{u_i}	PRS^{u_i}	LC^{u_i}	PRS^{u_i}	LC^{u_i}	PRS^{u_i}
δ (discount factor)	0.942***		0.939***		0.917***	
	(0.003)		(0.006)		(0.002)	
φ (punishment parameter)	0.374***		0.101***		0.263***	
	(0.002)		(0.003)		(0.000)	
σ (average coef. of RRA)	1.138***		0.943***		1.173***	
	(0.008)		(0.001)		(0.001)	
β_1/σ (education)	0.038***	0.425***	0.159***	0.114***	0.495***	0.214***
	(0.002)	(0.063)	(0.004)	(0.043)	(0.006)	(0.079)
β_2/σ (proportion of women)	1.353***	-0.104	-1.631***	-0.728**	3.253***	1.739***
	(0.003)	(0.179)	(0.022)	(0.298)	(0.004)	(0.320)
β_3/σ (age)	-0.036***	-0.003	0.023***	0.039***	-0.044***	-0.030***
	(0.001)	(0.003)	(0.003)	(0.004)	(0.001)	(0.004)
β_4/σ (land)	-0.181***	-0.025	-0.434***	-0.142***	-0.619***	0.014
	(0.006)	(0.093)	(0.004)	(0.027)	(0.002)	(0.030)
γ_c^2 (variance of cons. m.e.)	0.041***	0.047***	0.043***	0.040*	0.051***	0.052***
	(0.002)	(0.008)	(0.004)	(0.008)	(0.001)	(0.008)
γ_y^2 (variance of inc. m.e.)	0.058***		0.050***		0.085***	
	(0.000)		(0.000)		(0.000)	
Log likelihood	17.517	2.403	15.761	-0.031	35.036	-7.793
# of obs.	170	170	185	185	155	155
# of hholds	34	34	37	37	31	31

Notes: See Table 2.

E Descriptive statistics for the implied coefficients of relative risk aversion

This appendix shows descriptive statistics for the coefficient of RRA implied by the two models with heterogenous preferences. The aim is to get a sense of how much preference heterogeneity the estimated parameters imply. Table A4 presents the statistics by village, and also separately for two groups of households, poor and rich (below and above median average income, respectively), in each village. Note that a lower bound of 0.1 is imposed on the coefficient of RRA for each household.

In all cases the estimated heterogeneity parameters imply substantial heterogeneity in households' risk preferences. The coefficient of variation of the coefficient of RRA varies between 0.528 and 0.878 across models and villages.

Table A4: Descriptive statistics for the coefficient of relative risk aversion

	LC^{u_i}				PRS^{u_i}			
	Mean	Coef. of var.	Min	Max	Mean	Coef. of var.	Min	Max
	Aurepalle							
All households	1.084	0.616	0.221	2.369	1.000	0.739	0.333	3.034
Poor households	1.230	0.564	0.221	2.369	0.634	0.579	0.369	1.387
Rich households	0.937	0.669	0.278	1.989	1.366	0.615	0.333	3.034
	Kanzara							
All households	0.941	0.604	0.100	2.113	1.000	0.528	0.180	2.259
Poor households	1.019	0.554	0.244	2.113	0.990	0.527	0.348	2.030
Rich households	0.864	0.673	0.100	2.073	1.010	0.553	0.182	2.260
	Shirapur							
All households	1.180	0.878	0.100	3.296	1.000	0.604	0.178	2.330
Poor households	1.490	0.727	0.100	3.296	1.042	0.671	0.178	2.330
Rich households	0.849	1.063	0.100	2.251	0.955	0.526	0.198	1.770

Notes: Poor (rich) households are those with average income below (above) the village median.

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