Risk Sharing and Land Misallocation

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Spanish Macro Network
October 10-11, 2024

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- Resource misallocation across farms is major cause of productivity losses (Adamopoulos and Restuccia 14)
- **What drives poor allocative efficiency?**

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  - lack of property rights (Chari et al 21)
  - transaction costs (Ciaian and Swinnen 06)

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  - missing insurance markets distort farmers' investment in materials (Donovan 21)

Introduction

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What is the misallocation cost of imperfect consumption risk sharing?

In this paper...

- We build a model of risk-sharing across farmers subject to idiosyncratic shocks to show that limited insurance distorts land allocation

- We use farm-level data for India (ICRISAT) to document that, *across villages*, higher risk sharing is associated with lower misallocation, i.e.
    - higher correlation between farm productivity and land holding
    - lower dispersion in the marginal product of land

- We quantify aggregate losses from imperfect insurance vis-à-vis production distortions
    - moving from observed to full risk-sharing doubles size-productivity correlation, increases output p.c. by 19% (welfare in CEV by 14%)
        - $\approx 1/3$ of overall gains from moving to efficient allocation
    - output and welfare gains are robust to the inclusion of correlated distortions

- Unit measures of risk-averse farmer *types* $i \in \mathcal{I}$, characterized by
  - permanent productivity, θ_i
  - land endowment, $\bar{\ell}_i$
- Within each type i, there is a unit mass of ex-ante identical farmers, differing ex-post in the realization of an idiosyncratic iid shock, $\rho \sim Q(\rho)$
- Production function: $y_{i\rho} = \rho\theta_i\ell_i^{\alpha}, \quad \alpha \in (0,1)$
  - land holdings, ℓ_i, chosen before uncertainty is realized
- Consumption function: $c_i(\rho) = \exp[\beta \log \pi_{i\rho} + (1-\beta)\log f_i(\bar{y})]$
  - $\pi_{i\rho} = y_{i\rho} - r(\ell_i - \bar{\ell}_i)$ denotes idiosyncratic income
  - r denotes rental price of land
  - $f_i(\bar{y})$ is a i-specific function of average income
  - $\beta \in (0,1]$ governs the degree of risk sharing, i.e. $\beta = 1 \implies$ no insurance
- CRRA utility function, with RRA coefficient $\sigma > 0$

Planner's problem

For a given set of Pareto weights, $\{\nu_i\}_{i\in\mathcal{I}}$, the planner chooses an allocation for consumption $\boldsymbol{c}(\boldsymbol{\rho}) = \left(c_i(\rho)_{\rho\in P}\right)_{i\in\mathcal{I}}$ and land holdings $\boldsymbol{\ell} = (\ell_i)_{i\in\mathcal{I}}$ to maximize aggregate welfare:

$$\max_{\boldsymbol{c}(\boldsymbol{\rho}),\boldsymbol{\ell}} \int \nu_i \int \frac{c_i(\rho)^{1-\sigma}}{1-\sigma} \mathrm{d}Q(\rho)\,\mathrm{d}i,$$

subject to the land availability constraint

$$\int \ell_i \mathrm{d}i = \int \tilde{\ell}_i \mathrm{d}i = \bar{L},$$

and the feasibility constraint

$$\int\int c_i(\rho)\,\mathrm{d}Q(\rho)\,\mathrm{d}i = \int\int y_{i\rho} \mathrm{d}Q(\rho)\,\mathrm{d}i.$$

Proposition 1

- With perfect risk sharing,
  - each farmer within type i consumes a constant fraction of aggregate output, with the fraction being proportional to its Pareto weight, i.e.,

$$c_i(\rho) = \frac{\nu_i^{\frac{1}{\sigma}}}{\int \nu_j^{\frac{1}{\sigma}} \mathrm{d}j} \int \int y_{j\rho} \mathrm{d}Q(\rho) \, \mathrm{d}j$$

  - the expected marginal products of lands are equalized across farmer types, i.e.,

$$\int \alpha \rho \theta_i \ell_i^{\alpha-1} \mathrm{d}Q(\rho) = \int \alpha \rho \theta_j \ell_j^{\alpha-1} \mathrm{d}Q(\rho) \quad \forall i \neq j \in \mathcal{I}$$

    - the expected total income is maximized;
    - more productive households cultivate more land.

Competitive equilibrium without insurance

A competitive equilibrium in a village economy **without insurance** (i.e., $\beta = 1$) is an allocation of consumption $\{c_i(\rho)\}_{i \in \mathcal{I}}$, land holdings $\{\ell_i\}_{i \in \mathcal{I}}$ and a rental price of land r such that:

- *consumption function:*

$$c_i(\rho) = y_{i\rho} - r(\ell_i - \bar{\ell}_i), \ \forall i \in \mathcal{I}, \ \forall \rho \in P$$

- *land choice optimality:*

$$\ell_i \in \arg\max_{\ell_i \geq -\bar{\ell}_i} \int \frac{c_i(\rho)^{1-\sigma}}{1-\sigma} \mathrm{d}Q(\rho), \ \forall i \in \mathcal{I}$$

- *market clearing:*

$$\int \ell_i \mathrm{d}i = \int \bar{\ell}_i \mathrm{d}i = \bar{L}$$

Proposition 2

- Without insurance,
  - there is land misallocation across farmers; i.e., the farmers' expected marginal product of land is not all equal to its rental price:

$$\{\ell_i\}_{i\in\mathcal{I}} \quad \text{s.t.} \int \left(\alpha\rho\theta_i{\ell_i}^{\alpha-1} - r\right) c_i(\rho)^{-\sigma} \mathrm{d}Q(\rho) = 0$$

Relative to the case of perfect risk sharing, with no insurance,

- land choices aim to increase expected utility subject to the downside risk of renting before uncertainty is realized;
- risk-averse farmers overvalue the states of the world where consumption is low (ρ is low)
  - low-productivity farmers overbuy lands to insure themselves;
  - high-productivity farmers underbuy because of large losses from negative shocks due to complementarity in production.

Proposition 3

- Let the consumption function for a household of type i be

$$c_i(\rho) = \exp\left\{\beta \log\left(\pi_{i\rho}\right) + (1-\beta)\log\left(\frac{\nu_i^{\frac{1}{\sigma}}}{\int \nu_j^{\frac{1}{\sigma}} \mathrm{d}j} \int \int \pi_{j\rho} \mathrm{d}Q(\rho)\, \mathrm{d}j\right)\right\} \quad \forall \rho \in P$$

where $\beta \in (0, 1]$. Then, land misallocation increases with the elasticity of consumption with respect to own income, β.

Data & Evidence

- Household panel data collected under the Village Dynamics in South Asia (VDSA) project by ICRISAT
  - it covers rural households (farms) across 18 villages in the Indian semiarid tropics, years 2009-2014
  - yearly information on farm-level output and prices, material expenditure, hours worked, land holdings, soil quality, rainfall, health
    - farm physical productivity from production function estimation (Cobb-Douglas)
  - monthly information on farm-level consumption expenditure and income

- Descriptive evidence:
  - distribution of land across farms tilted towards small size
  - distribution of productivity across farms largely dispersed
  - imperfect consumption insurance

- **Step 1.** Estimate the degree of risk sharing separately for every village v and year τ:

$$\log c_{it} = \beta_{v(i)\tau(t)} \log \pi_{it} + \mu_t + \mu_i + \epsilon_{it}$$

where c_{it} and π_{it} are monthly consumption expenditure and income of farm i (of village v) at time t (within year τ)

Land misallocation & risk sharing across Indian villages

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- **Step 2.** Correlate risk sharing to measures of misallocation at the village-year level

$$\omega_{v(i)\tau(t)} = \gamma_0 + \gamma_1 \hat{\beta}_{v\tau} + \mu_v + \mu_\tau + \varepsilon_{v\tau}$$

  where $\omega_{v\tau}$ are measures of misallocation, such as:

  - covariance between land holding, ℓ_{it} and farms' physical productivity, $\hat{\theta}_i$, $\text{corr.}_{v\tau}[\ell_{it}, \hat{\theta}_i]$
  - dispersion of (log) marginal product of land, $\text{st.dev.}_{v\tau}[\log \text{MPL}_{it}]$

Land misallocation & risk sharing across Indian villages

	corr.$_{v\tau}$ $\left[\log \ell_{i\tau}, \log \widehat{\theta}_i\right]$				st.dev.$_{v\tau}$ $\left[\log \text{MPL}_{i\tau}\right]$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\widehat{\beta}_{v\tau}$	-0.648***	-0.675***	-0.163**	-0.229***	0.732***	0.749***	0.161***	0.192***
	(0.226)	(0.228)	(0.080)	(0.109)	(0.178)	(0.245)	(0.063)	(0.076)
N.Obs.	90	90	90	90	90	90	90	90
R-squared	0.106	0.118	0.897	0.942	0.218	0.223	0.902	0.948
Village FE		✓	✓	✓		✓	✓	✓
Year FE			✓	✓			✓	✓
Village time trends				✓				✓

- Lower risk sharing (higher $\hat{\beta}_{v\tau}$) associated with lower correlation between productivity and land holding and higher dispersion
- Measure of caste diversity across villages to address endogeneity of $\hat{\beta}_{v\tau}$

What are the aggregate gains from full insurance?

- Extend quantitative framework to include production distortions τ_i (Bento and Restuccia 16)

$$y_{i\rho} = \rho\theta_i(1 - \tau_i)\ell_i^{\alpha}$$

where $\tau_i = 1 - \theta_i^{-\zeta}$ are allowed to be correlated with productivity θ_i, through the parameter ζ

- Fit the model to the average village in our data
  - Assumption: equal Pareto weights across farmers, $\nu_i = \nu_j, \forall i \neq j$

- Two main experiments:
  - counterfactual change in risk sharing to validate the model against evidence across villages
  - horse race between incomplete risk sharing vs distortions

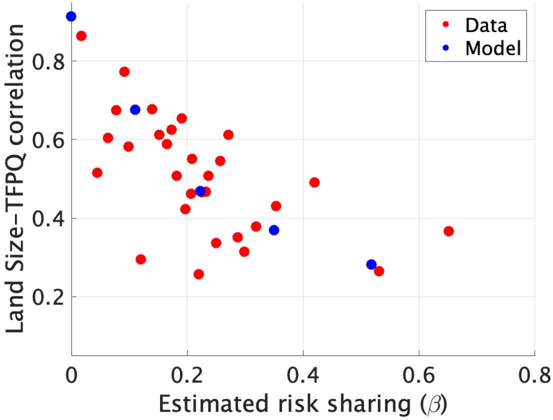
Estimated parameters

- Estimate the degree of risk-sharing, β, externally, using Townsend (94) test of complete insurance $\implies \beta = 0.223$

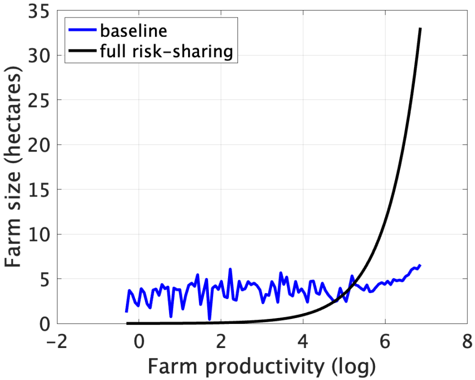
- Estimate relative risk aversion, σ, to match cov.$[\log \ell_{it}, \log \hat{\theta}_i] = 0.461 \implies \hat{\sigma} = 1.647$

- Estimate distortion correlation, ζ, to match a share of farmers with $\ell_i \leq 5$ hectares $= 0.801 \implies \hat{\zeta} = 0.052$

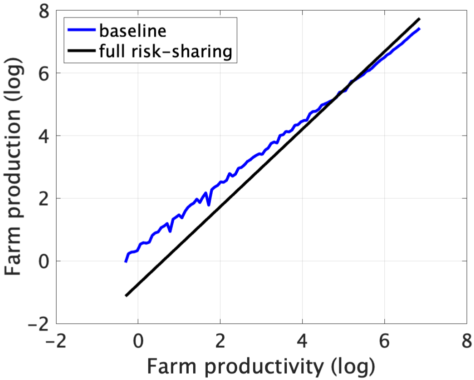
Risk-sharing and Misallocation: Model vs Data



- Everything else fixed, the model generates cross-village correlation between estimation risk sharing $1 - \hat{\beta}$ and the covariance between land size and TFP-Q

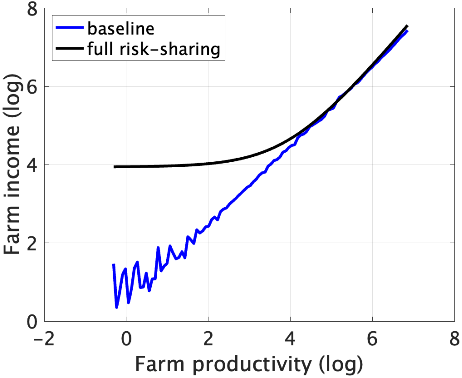

baseline
full risk-sharing
Farm size (hectares)
Farm productivity (log)
35
30
25
20
15
10
5
0
−2
0
2
4
6
8

(a)

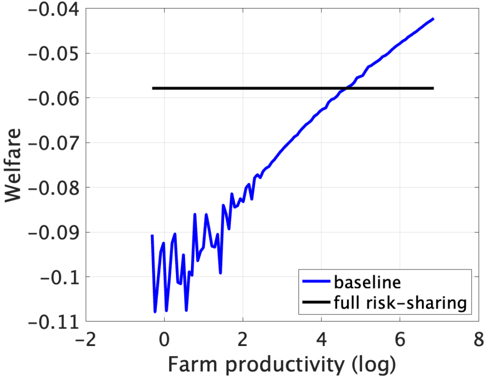

baseline
full risk-sharing
Farm production (log)
Farm productivity (log)
8
6
4
2
0
−2
−2
0
2
4
6
8

(b)

Mechanics of full risk sharing



(c)



(d)

Output gains from full-insurance

	Baseline	Counterfactual	
	(1)	(2)	(3)
β	0.223	0	0
ζ	0.052	0.052	0
Aggregate efficiency (output per hectare)	1	1.393	1.896
Aggregate output	1	1.186	1.614
Aggregate welfare	1	1.137	1.158

- Output gains from moving to full insurance equal to 19%
  - $\approx 1/3$ of overall gains from moving to efficient allocation
- Comparable to gains/losses from farm-specific land policies:
  - ceiling on land holdings $\approx$ -17% (Adamopoulos and Restuccia 20)
  - allowing land leasing $\approx$ 8% (Chari et al 21)

Conclusion

- We theoretically show that limited consumption risk-sharing distorts land allocation across farmers, even in *undistorted* land markets
- We use farm-level data for India to document that villages with a higher degree of risk sharing have better allocation efficiency in land holdings
- We quantify aggregate gains from perfect insurance:
  - +19% in output p.c., + 39% in land efficiency, +14% in welfare (CEV)
- Relatively less important role for production distortions
  - Chen et al (23) find a 1.7-fold gain in moving to undistorted economy

	ICRISAT, 10-14	World Census of Agriculture, 90		
	India	Malawi	Belgium	United States
Hectares (Ha):				
$\leq$ 1 Ha	17.93	77.7	14.6	–
1 – 2 Ha	23.88	17.3	8.5	–
2 – 5 Ha	38.26	5.0	15.5	10.6
5 – 10 Ha	13.45	0.0	14.8	7.5
$\geq$ 10 Ha	6.49	0.0	46.6	81.9
Average Farm Size (Ha)	3.82	0.7	16.1	187.0

- Average farm size of 3.82 hectares
- Distribution of land across farms tilted towards small size

- We pose the following farm-level production function:

$$y_{i\tau} = e^{\mu_\tau} e^{\vartheta \text{rain}_{v(i)\tau}} \rho_{i\tau} \theta_i (k_{i\tau}^{\alpha_1} h_{i\tau}^{\alpha_2})^{\eta_1} (q_{i\tau}^{\alpha_3} \ell_{i\tau})^{\eta_2}, \qquad \alpha_1, \alpha_2, \eta_1, \eta_2 \in (0,1), \alpha_3 > 0$$

  where $y_{i\tau}$ denotes output (deflated using farm-product-level prices) of farm i in year τ, μ_τ capture common year-specific factors, $k_{i\tau}$ is farm's capital, $h_{i\tau}$ denotes # hours worked, $\ell_{i\tau}$ is land holding, $q_{i\tau}$ denotes soil quality.

- Farmer's productivity is assumed to be

$$\log \theta_i = \mu_i,$$

  where μ_i denotes farmer i's permanent productivity

- We estimate the following farm-level regression using OLS

$$\log y_{i\tau} = \widehat{\vartheta}\text{rain}_{v(i)\tau} + \gamma_1 \log k_{i\tau} + \gamma_2 \log h_{i\tau} + \gamma_3 \log q_{i\tau} + \gamma_4 \log \ell_{i\tau} + \mu_\tau + \mu_i + \varepsilon_{i\tau},$$

where $q_{i\tau}$ is parametrized as

$$\log q_{i\tau} = \delta_1 \text{depth}_{i\tau} + \delta_2 \text{slope}_{i\tau} + \delta_3 \text{fertility}_{i\tau} + \delta_4 \text{degradation}_{i\tau}$$

- Farmer-specific productivity is the estimated fixed-effect:

$$\log \theta_i = \hat{\mu}_i$$

- The idiosyncratic shock is the predicted residual:

$$\log \hat{\rho}_{i\tau} = \hat{\varepsilon}_{i\tau}$$

TFP-Q distribution

	Farms			Manufacturing firms		
	India 2010-2014	Malawi 2010-2011	US 1990	India 1987	China 1998	US 1977
St.dev., log	1.08	1.18	0.80	1.16	1.06	0.85
75-25 log ratio	1.02	1.39	1.97	1.55	1.41	1.22
90-10 log ratio	2.50	2.89	2.50	2.77	2.72	2.22

- Dispersion of TFP-Q across agricultural farms comparable to those of Malawi and the US

Input Contribution in Agricultural Output

Variable	R-squared (1)	Shapley value (%) (2)
Rainfall shocks: Var $\left[\widehat{\vartheta}\text{rain}_{v(i)\tau}\right]$	0.004	0.160
Land quality, Var $\left[\log \widehat{q}_{i\tau}\right]$	0.103	3.480
Household-farms' physical productivities: Var $\left[\log \widehat{\theta}_i\right]$	0.614	41.68
Family labor: Var $\left[\log h_{i\tau}\right]$	0.382	19.07
Capital: Var $\left[\log k_{i\tau}\right]$	0.292	10.10
Landholdings: Var $\left[\log \ell_{i\tau}\right]$	0.277	10.05

- Dispersion of TFP-Q across agricultural farms explains a large share of output dispersion

Risk-sharing in the ICRISAT villages

	$\log c_{it}$	$\Delta \log c_{it}$	
	OLS	OLS	IV
	(1)	(2)	(3)
$\log y_{it}$	0.225***		
	(0.0181)		
$\Delta \log y_{it}$		0.206***	0.230***
		(0.0194)	(0.0048)
Household FE	✓		
Village-month FE	✓	✓	✓
Observations	46369	41263	29601
R-squared	0.681	0.319	0.193
First-stage F-statistic			574.54

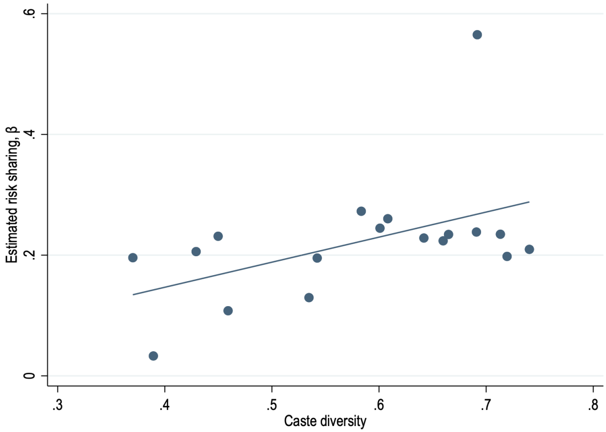
- Risk sharing is not perfect: the elasticity of consumption to income changes is 22.5%

- Let n_{jv} be the number of households belonging to a caste group $j \in \mathcal{J}$ in village v, with $\sum_{jv} n_{jv} = n_v$
- We construct a measure of caste diversity in village v as 1 minus the Simpson's Diversity Index:

$$z_v = 1 - \frac{\sum_{j \in \mathcal{J}} n_{jv} \left(1 - n_{jv}\right)}{n_v \left(1 - n_v\right)}.$$

- We use z_v to instrument $\widehat{\beta}_{v\tau}$

First-stage



- First-stage regression: $\widehat{\beta}_{v\tau} = \varrho + \gamma z_v + \mu_\tau + \epsilon_\tau$
- Slope=0.415 (0.126), F-stat=10.87, N=90

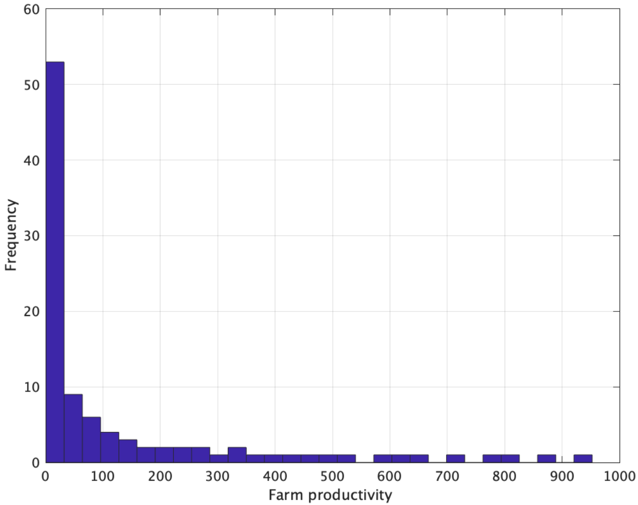
	$\text{corr.}_{v\tau}\left[\log \ell_{it}, \log \widehat{\theta}_i\right]$ (1)	$\text{st.dev.}_{v\tau}\left[\log \text{MPL}_{it}\right]$ (2)
$\widehat{\beta}_{v\tau}$	-1.331**	2.095***
	(0.574)	(0.579)
N.Obs.	90	90
R-squared	0.783	0.858

- Lower risk sharing associated with lower correlation between productivity and land holdings and higher dispersion

External parameters

Parameters	Description	Value	Source
α	Land share	0.282	Production function estimation
θ	Permanent productivity		Production function estimation
ρ	Idiosyncratic shocks		Production function estimation
L	Aggregate land supply (hectares)	3.819	Directly measured from the data

Productivity distribution



Idiosyncratic shock distribution