Sharing Risk to Avoid Tragedy: Informal Insurance and Irrigation in Village Economies

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Research Question & Motivation

What is the interaction btw insurance of idiosyncratic shocks (risk sharing) and irrigation?

- By insuring aggregate risk, investments into irrigation may lower demand for risk sharing.
- Access to risk sharing (ostracism, social norms) may be used to elicit better co-operation over irrigation.

I argue that this interaction is quantitatively significant. Thus, important from policy perspective in places relying heavily on irrigation, e.g. India (in 2016 8.5% of gov spending on irrigation).

Village Economy

- N of ex post heterogenous, infinitely lived farmers.
- **Crop output** of farmer i: $y_{i,t} = \phi_t \cdot \theta_{i,t}$.
- **Idiosyncratic risk** $\theta_{i,t}$ (machine & crop failures, health shocks):
  - Can be mitigated through informal insurance.
  - Drawn from a Markov chain with moments $E(\theta)$ and $Var(\theta)$.
- **Aggregate risk** ϕ_t (droughts):
  - Can be mitigated by investments into irrigation-capital stock depreciating at rate δ.
  - Investments by farmers $\frac{1}{1-s_k}\mathbf{k}_t = \frac{1}{1-s_k} \cdot [k_{1,t}, \dots, k_{N,t}]$ are subsidized at rate s_k and excludable. Also provide self-insurance.
  - Investments by government ω are financed by resources from outside, non-excludable.
  - ϕ_{t+1} is drawn from either of two Markov chains:
    - "Good" one with probability $P\left(\frac{1}{1-s_k}\mathbf{k}_{t+1}, \omega\right)$.
    - "Bad" one with prob. $1 - P\left(\frac{1}{1-s_k}\mathbf{k}_{t+1}, \omega\right)$.
    - s.t. $E(\phi^G) > E(\phi^B)$ & $Var(\phi^G) < Var(\phi^B)$.
- **Co-operation:**
  - Scope for co-op: 1) insurance against idiosyncratic shocks; 2) co-ordinating and sharing investments into irrigation.
  - Subject to limited commitment: in every period & state $Value\ of\ coop \geq Value\ of\ non-coop$.
  - Punishments: if farmers default on assigned risk sharing or irrigation investments, they get permanently excluded from:
    - risk sharing network (keep self-insurance),
    - irrigation owned by other villagers (keep access to own and government-owned irrigation).

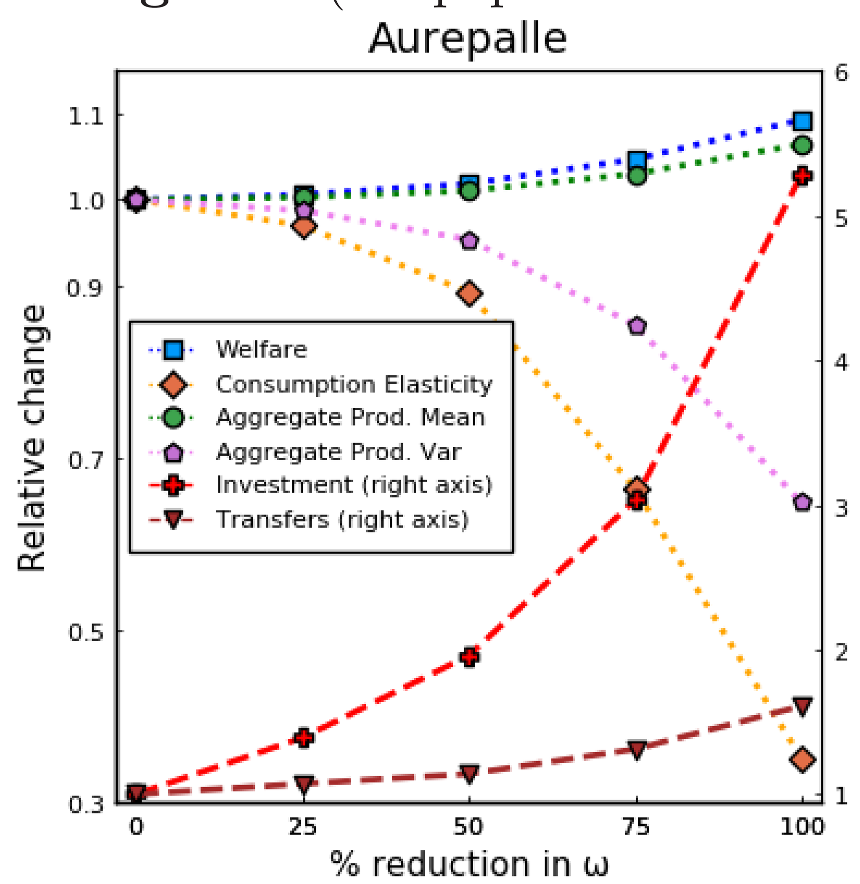
Estimation on ICRISAT panel

Indirect inference approach based on 1st wave of ICRISAT (1976-1984), 1st Minor Irrigation Census (MIC) and precipitation data from UDelaware:

- Focus on 3 villages: Aurepalle, Kanzara, Shirapur.
- Match elasticity of consumption w.r.t. idiosyncratic income shocks from Townsend consumption smoothing test.
- Match the variance and persistence of idiosyncratic risk process from Storesletten et al. (2004) decomposition.
- Match variance of average village income and persistence of empirical rainfall process.
- Match returns to irrigation from: $\log(y_{i,t}) = \alpha + \beta_1 1^D_{v,t} + \beta_2 irr_{i,t} + \beta_3 1^D_{v,t} \cdot irr_{i,t} + \beta_4 \cdot X_i + \gamma_t + \epsilon_{i,t}$, where $1^D_{v,t}$ is 1 if draught village-year, $irr_{i,t}$ is irrigated share of land.
- Directly from data: depreciation rate, share of gov-owned irrigation and subsidy rate s_k.
- Calibration fit very good (see paper).

Result #2: Reduce Gov Irrig

Counterfactual of **reducing the size of gov-owned irrigation** (see paper for other villages):



Result #1: Model and Estimation Validation

Combining 1st wave of ICRISAT & 1st MIC with (unused in estimation) 2nd wave of ICRISAT (2001-2004) & 4th MIC, I run **the extended consumption smoothing test** both on the actual and simulated data:

$$\log(cons_{i,t}) = \alpha + \beta_1 \log(y_{i,t}) + \beta_2 \log(y_{i,t}) \cdot irr_{v,t} + \beta_3 \log(y_{i,t}) \cdot irr_{v,t} \cdot gov_{v,t} + \beta_4 \log(y_{i,t}) \cdot gov_{v,t} + \tilde{\beta}_i + \gamma_{v,t} + \epsilon_{i,t}$$

Estimates		
Dep var: consumption	Data	Model
income	0.31*** (0.07)	0.30*** (0.003)
income·irrigation	-0.57*** (0.17)	-0.29*** (0.02)
income·irrigation·government share	6.70*** (1.94)	1.32*** (0.12)
income·government share	-0.71 (0.42)	0.12*** (0.01)
Implied effects on consumption elasticity		
Government share 1 st.dev. increase	26%	18%
Irrigation 1 st.dev. increase	-9%	-12%

Although untargeted in estimation, I find that:

- Signs of regressions closely matched.
- Estimates differ btw data and model due to different measurement units of irrigation used.
- However, implied economic effects close to each other.
- This validates both the modeling assumptions and structural estimation strategy.

Further validation: avg (across 3 villages) saving rate 10%, close to evidence in Rosenzweig and Wolpin (1993).

Result #3: Interaction Between Risk Sharing and Irrigation

I solve for two counterfactual allocations:

- **irrigation only (I):** households with self-insurance (no state-contingent risk sharing) and access to both community- and government-owned irrigation,
- **risk sharing only (RS):** households engage into risk sharing, and have access only to own and government-owned irrigation.

Statistic	Aurepalle			Kanzara			Shirapur		
	I+RS	I	RS	I+RS	I	RS	I+RS	I	RS (=NC)
Welfare									
Cons.-eq. welfare	1	0.90	0.97	1	0.98	0.96	1	0.93	0.84
Irrigational Investments and Production									
Mean invest. k'	0.05	+87%	-3%	0.02	+34%	-10%	0.08	+42%	-12%
Var. of invest. k'	0.01	+227%	+12%	0.01	+103%	-20%	0.01	+147%	+46%
Mean aggr. prod. ϕ	0.87	+1%	-2%	0.87	+1%	-3%	0.88	+1%	-7%
Var. aggr. prod. ϕ	0.05	-6%	+8%	0.06	-3%	+11%	0.05	-7%	+23%
Consumption and Risk Sharing									
Mean consumption	0.44	+1%	-2%	0.44	+1%	-3%	0.43	+1%	-7%
Var. consumption	0.02	+181%	+4%	0.02	+57%	+15%	0.02	+184%	+175%
Cons. elasticity	0.38	+156%	+5%	0.35	+185%	+16%	0.32	+159%	+178%
Transfers	0.25	-100%	-3%	0.18	-100%	-10%	0.27	-100%	-100%

Removing risk sharing co-op (cf. I+RS vs I):

1. Reduces efficiency of irrigational investments.
2. Worsens consumption insurance (state-contingent risk sharing transfers vs. simple self-insurance)
3. Villagers willing to pay btw 2%-10% of consumption to keep co-op over risk sharing.

Removing irrigation co-op (cf. I+RS vs RS):

1. Lowers investment (externalities ignored).
2. Worsens risk sharing (consumption elasticity up).
3. Significantly destabilises co-operation in Shirapur (without irrigation coop, risk sharing is impossible).
4. Villagers willing to pay btw 3%-16% of consumption to keep co-op over irrigation.