Risk and the modernization of agriculture

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Two mechanisms through which risk of extreme weather events affects farmers

1. Direct costs through damages to crops, homes, livestock, etc.
2. Self-insurance - conservative decisions that reduce risk at expense of lower profitability (Binswanger and Rosenzweig, 1993; Morduch, 1995)
   - Crop / variety choice
   - Level of input use
   - Management techniques (i.e. how to plant)

Our question focuses on the second mechanism

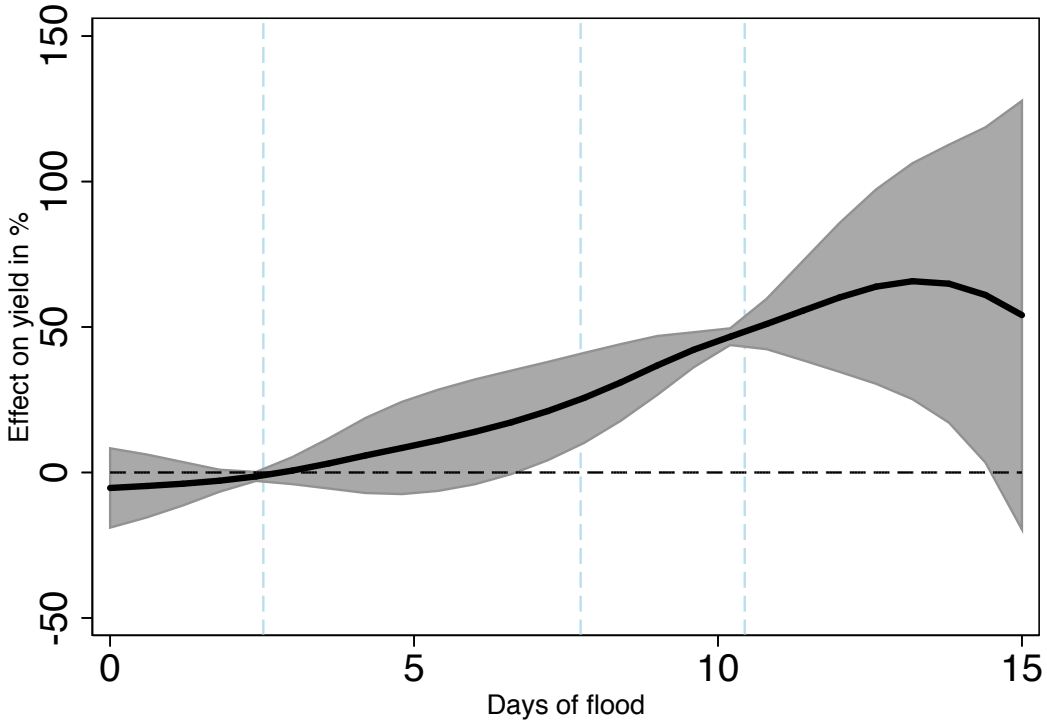
- *Question*: Can new technologies that make agricultural output less susceptible to weather extremes crowd in investments that were previously too risky?
  - $\longrightarrow$ If so, technologies can boost agricultural output **in normal years**

Approach

1. Two year field experiment in 128 villages of Odisha India
2. Allocate 5kg of flood-tolerant rice seeds "Swarna-Sub1" to a random subset of farmers (5 farmers in each of 64 villages)
3. Large floods occurred in many villages during year 1 (2011)
   Farmers misfortune = Experimenter's luck:
   → **Verify the agronomic properties of Swarna-Sub1**
4. Observe changes in behavior in year 2 (2012)
   Normal rainfall: Farmers' good luck = Experimenter's good luck
   → **Large changes in investment, but also in savings and credit use**
   → **Large aggregate effect on yield and on production**
   → **Because there was no flood, aggregate effect on production solely due to behavioral change**

Agronomic value measured in year 1

- Swarna-Sub1: A flood-tolerant rice variety
  - Similar to Swarna, a common variety used throughout eastern India
  - Enhanced flood tolerance, especially for 5-14 days of flood
  - Similar yield without flooding
  - → Technology increases expected yield and reduces variance
  - Also pro-poor due to higher flood exposure for low caste (long historical marginalization toward less favorable lands)



Source: Dar et al. (2013)

Sub1 works by suppressing elongation response

Theoretical framework

- Model
  - Standard multiperiod household model
  - Production is risky (flood/ no-flood after input choices)
  - Return to inputs lower under flood conditions
  - Modern technology increases return to inputs under flood, no difference under normal conditions, i.e., protection under downward risk with no penalty.
- Predictions
  - [Productivity effect] Technology increases *expected return* to inputs $\rightarrow$ increases investment in inputs.
  - [Insurance effect] Technology reduces losses in bad states $\rightarrow$ allows to reduce risk mitigation behavior and precautionary savings. Effect $\uparrow$ with risk aversion

All specifications are ITT

- Either at the farmer or plot level:

$$y_{ivb} = \beta_0 + \beta_1 treatment_{ivb} + x_{ivb}\delta + \alpha_b + \varepsilon_{ivb}$$

$$y_{ipvb} = \beta_0 + \beta_1 treatment_{ivb} + x_{ivb}\delta + \alpha_b + \varepsilon_{ipvb}$$

  - i is farmer, p is plot, v is village, and b is block (strata)
  - SE's clustered at village level
  - 25% of farmers dis-adopted during year 2, 10% adopted from peers.

ITT results robust to dropping non-recipients in treatment villages

Outcomes of interest

- **Inputs / Management Practices**
  - Rice area
  - Fertilizer use, concentrated on fertilizers used earlier in growing season
  - Use of "traditional varieties"
  - Planting method
- **Yield in kg per ha**
- **Credit**
- **Precautionary savings**

Flood tolerance increases area cultivated

	(1) Number plots	(2) Rice area	(3) Log rice area
Original minikit recipient	0.675***	0.102*	0.090**
	(0.125)	(0.055)	(0.044)
ST or SC	-0.252	-0.032	-0.048
	(0.156)	(0.052)	(0.055)
HH has BPL card	-0.001	-0.147***	-0.105**
	(0.115)	(0.051)	(0.045)
HH has thatched roof	-0.391***	-0.208***	-0.207***
	(0.119)	(0.052)	(0.047)
Block Fixed Effects	Yes	Yes	Yes
Mean of Dep Variable	3.57	1.00	-0.20
Number of Observations	1235	1235	1173
R squared	0.112	0.136	0.186

Flood tolerance increases use of "early" fertilizers

	(1)	(2)	(3)	(4)	(5)
		Latest	Earliest	Middle	
	All	Urea	DAP	MOP	Gromor
Original minikit recipient	24.622**	3.329	18.347***	5.940*	-2.993
	(10.002)	(4.235)	(5.282)	(3.213)	(2.637)
Rice area (hectares)	217.515***	86.801***	89.468***	32.445***	8.802***
	(19.379)	(13.401)	(9.272)	(7.027)	(2.567)
Scheduled Tribes	-17.964*	-3.952	-5.363	-5.040*	-3.609
or Scheduled Castes	(9.574)	(3.748)	(4.579)	(2.947)	(2.602)
HH has Below-Poverty-	-1.348	-0.933	-4.993	1.480	3.098
Line card	(9.021)	(4.041)	(4.306)	(2.440)	(2.456)
HH has thatched roof	-18.801**	-7.489**	0.247	-6.292**	-5.267**
	(8.400)	(3.572)	(4.502)	(2.653)	(2.481)
Block Fixed Effects	Yes	Yes	Yes	Yes	Yes
Mean of Dep Variable (kg)	215.49	83.33	79.99	37.15	15.01
Number of Observations	1235	1235	1235	1235	1235
R squared	0.615	0.508	0.518	0.288	0.074

Aside: "Traditional varieties" less likely to die during flood

- Traditional seed varieties are pre Green Revolution
- Low yield, but often less risk of failure

Aside: Transplanting rice vs. broadcasting

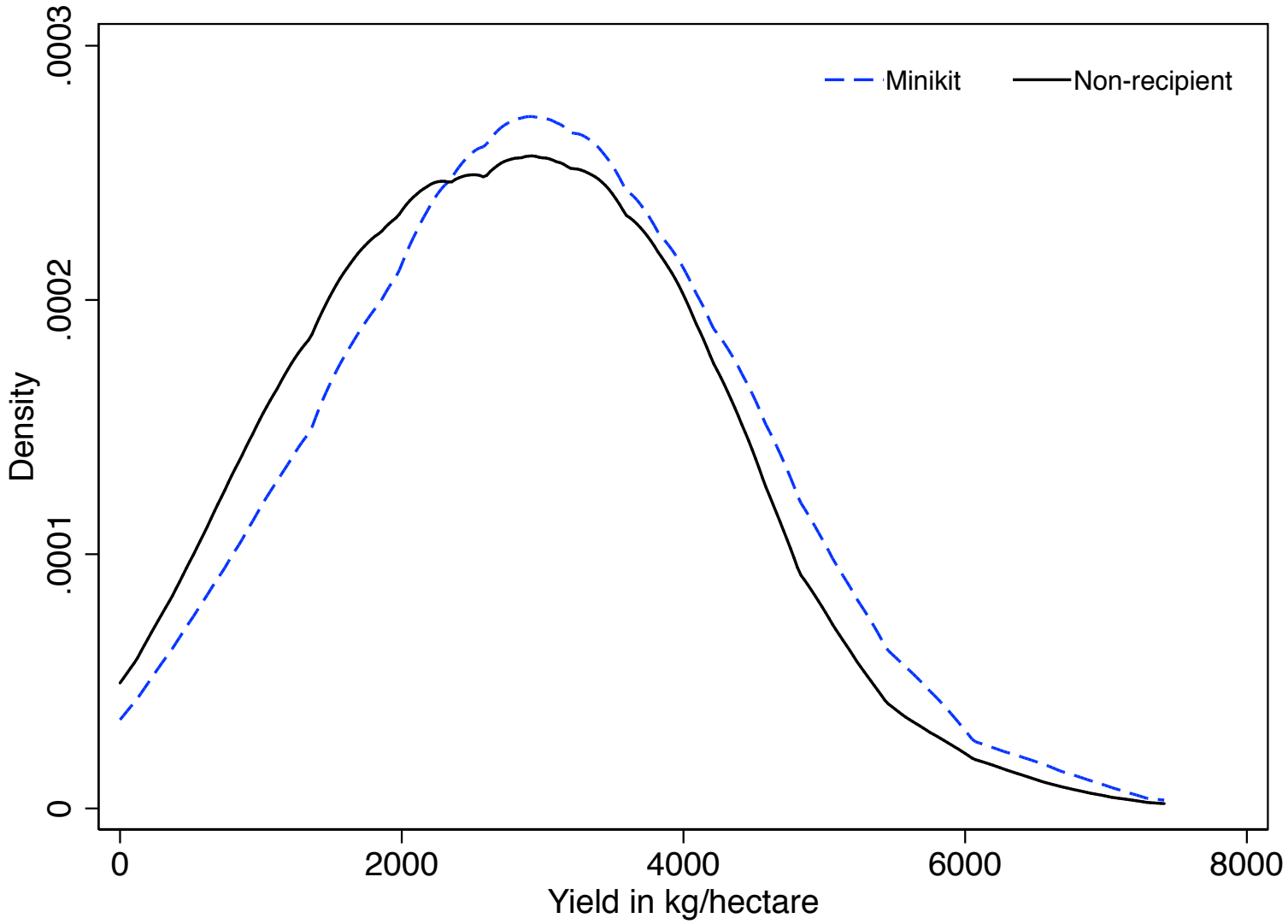
Labor intensive transplanting

Low yielding broadcasting

Flood tolerance induces risk-taking

	(1) Use Swarna	(2) Use TV	(3) Broadcast	(4) Irrigated	(5) Not cult.
Original minikit recipient	-0.102***	-0.041**	-0.063***	0.036	-0.023*
	(0.017)	(0.016)	(0.017)	(0.029)	(0.012)
ST or SC	0.041	-0.008	-0.029	-0.031	-0.013
	(0.025)	(0.022)	(0.028)	(0.041)	(0.016)
HH has thatched roof	-0.020	0.023	0.009	0.025	0.004
	(0.017)	(0.019)	(0.023)	(0.028)	(0.013)
HH has BPL card	-0.020	0.013	0.020	-0.026	-0.006
	(0.018)	(0.020)	(0.021)	(0.029)	(0.013)
Block Fixed Effects	Yes	Yes	Yes	Yes	Yes
Mean of Dep Variable	0.36	0.28	0.19	0.74	0.08
Number of Observations	4578	4577	4571	4546	5057
R squared	0.116	0.270	0.243	0.080	0.020

Effect on average productivity is 283 kg per ha, or 10%



Flood tolerance crowds in agricultural credit

	Has credit		
	(1) All	(2) Early	(3) Late
Original minikit recipient	0.068**	0.054**	0.017
	(0.027)	(0.025)	(0.017)
ST or SC	-0.048**	-0.050**	0.008
	(0.023)	(0.024)	(0.020)
HH has BPL card	-0.032	-0.013	-0.016
	(0.024)	(0.022)	(0.015)
HH has thatched roof	-0.014	-0.032	0.018
	(0.024)	(0.022)	(0.014)
Block Fixed Effects	Yes	Yes	Yes
Mean of Dep Variable	0.19	0.14	0.05
Number of Observations	1235	1235	1235
R squared	0.063	0.062	0.028

Flood tolerance crowds out precautionary savings

	Share saved		Log KG saved	
	(1)	(2)	(3)	(4)
Original minikit recipient	-0.050***	-0.087***	-0.045	-0.102**
	(0.017)	(0.026)	(0.032)	(0.046)
HH has BPL card	-0.001	-0.018	-0.026	-0.053*
	(0.018)	(0.020)	(0.026)	(0.028)
Original minikit recipient*HH has BPL card		0.067**		0.102*
		(0.030)		(0.054)
Log total harvest			0.771***	0.772***
			(0.018)	(0.018)
Block Fixed Effects	Yes	Yes	Yes	Yes
Mean of Dep Variable	0.70	0.70	7.16	7.16
Number of Observations	1165	1165	1153	1153
R squared	0.073	0.077	0.792	0.792

Combined, results suggest risk strongly influences decisions

Effects measured during year 2 (normal year following a bad year):

- **Inputs / Management Practices**
  - 10% increase in rice area
  - 11% increase in fertilizer use, concentrated on fertilizers used earlier in growing season
  - 15% less reliance on low return, low risk "traditional varieties"
  - 33% less use of "broadcast" planting method vs. more costly transplanting

  $\longrightarrow$ Approx 10% increase in yield
- **Precautionary Savings:** 5 pp less savings of output for future consumption
- **Credit:** 36% increase in credit use

Main explanation is that reduction in risk drives results

But, other explanations are possible:

1. Increased expected return
   Swarna-Sub1 reduces exposure to downward risk without penalty in good years
   $\rightarrow$ increases expected return *and* reduces risk

   Both effects can be responsible for:

   - Increased investment in inputs, both extensive and intensive margins
     $\rightarrow$ increase in yield and in production
   - Increased in credit
   - Reduction in share of production saved

Can we distinguish these two effects?

Main explanation is that reduction in risk drives results

What reveals the role of risk reduction versus increase in expected return?

- Fertilizer effects concentrated on fertilizers applied early in the season
  Early and late fertilizers are mildly complementary
  So any difference is due to decrease in risk during the growing season
- Land brought into production is low quality land, and land more prone to flood
- Results are generally larger for most risk averse farmers
- Share of production that is saved is lower *at any given level of production*

- Unlikely to be about production function b/c effects persist even on non-Sub1 plots

Main explanation is that reduction in risk drives results

Two other potential explanations:

1. Wealth effects
   Could increased production during year 1 drive results?
   Unlikely because:
   - Only small amount of seed during year 1
     $\longrightarrow$ Small aggregate income effects
   - Conditioning on year 1 harvest does not change results

2. Output prices
   Unlikely because:
   - Output price of Swarna-Sub1 higher than Swarna by 4.6%.
   - But, only 40% of farmers sold any output at all
   - Results are similar for sub-sample that did not sell output

Conclusions

- Risk reduction through weather resilient technology helps:
  - Cope with shocks in bad years
  - Reduce risk management/self-insurance in normal years
- Average gain in normal years from risk management (283kg) about equal to average avoided losses in bad years from shock coping (250kg)
- If there are more normal than bad years, risk management gains (behavioral spillover effects) exceed gains from shock coping (agronomic intended purpose) in expected value