Risk and Uncertainty[1]

Pierre Biscaye

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Outline

Business optimization

- Firms solve something like $\max pF(K, L; A) - rK - wL$
- If there are separation failures for household-producers, may solve $\max E[u(pF(K, L; A - r^*K - w^*L), \bar{L} - L)]$

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- Firms solve something like $\max pF(K, L; A) - rK - wL$
- If there are separation failures for household-producers, may solve $\max E[u(pF(K, L; A - r^*K - w^*L), \bar{L} - L)]$
- But firms may face *risk or uncertainty* in their production decisions
  - Uncertainty around prices of output or inputs
  - Uncertainty around availability or quality of inputs
  - Uncertainty around external factors affecting production
- Then firms solve something like $\max E[pF(K, L; A) - rK - wL|X]$, were X are known factors that affect expectations

Example sources of production risk and uncertainty

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- Supply chain disruptions
  - Delays or shortages in raw materials, intermediate goods, or logistics bottlenecks
- Equipment or machinery failure
  - Downtime due to maintenance issues, unexpected breakdowns, or power outages
- Labor availability
  - Risk of insufficient or unskilled labor due to strikes, turnover, or demographic shifts
- Natural disasters and extreme weather
  - Events like floods, hurricanes, or earthquakes that disrupt operations or damage infrastructure
- Market price volatility
  - Fluctuations in input or output prices that impact profitability and production planning

Production risk in developing countries

- Supply chain disruptions
  - Worse transport infrastructure and networks, weak enforcement of contracts
- Equipment or machinery failure
  - Poor power infrastructure
- Labor availability
  - Less access to skilled labor, greater prevalence of diseases
- Natural disasters and extreme weather
  - Greater vulnerability in many countries, limited tools for early warning, prevention, mitigation, and relief
- Some challenges more specific to the these contexts:
  - Political instability and weaker institutions
  - Limited credit, insurance, and financial markets

Particular challenges for poor farmers

- Production function uncertainty
  - Weather risk: rainfall variability, drought, heat waves
  - Risk from pests and diseases
  - Post-harvest losses
- Input uncertainty
  - Land tenure insecurity and uncertain property rights
  - Health of labor force
- Price uncertainty
  - Seasonality of production and prices
  - Limited connections to buyers, limited access to and information about markets and prices

Potential responses to risk and uncertainty

- **Financial mechanisms** and **precautionary behavior**: insurance, hold more liquid assets, establish access to credit
- **Risk aversion**: underinvestment, tradeoffs in risk vs returns in investments
- **Input allocation**: diversification $\Rightarrow$ risk-efficiency tradeoffs
- **Output diversification**: engage in different activities, spread risk $\Rightarrow$ reduce specialization and economies of scale
- **Forecasting**: invest in technologies to improve ability to predict outcomes and reduce (some) uncertainty

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The **upshot**: potential for increased costs and decreased productivity and profits

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Upshot: Risk affects production decisions differently with market and separation failures

Ex-post vs ex-ante risk smoothing

- Risk and uncertainty means there will be variation in realized incomes
- Household-producers want to *smooth* income and thus consumption
- **Ex-post smoothing**
  - Accept that you will have lower income in some periods
  - Deal with consequences: insurance, borrowing, saving, seek out other income sources, etc.
  - Better able to deal with risk $\Rightarrow$ more willing to take risk
  - What if financial markets are constrained?

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  - What if financial markets are constrained?
- **Ex-ante smoothing**
  - Try to prevent income volatility (most of the previous potential responses)
  - Alter income strategies to reduce potential income variation
  - Reduced variance may come at the expense of income levels

Ex-ante smoothing examples for household-producers

- Agriculture
  - Wait until monsoon realization to plant
  - Plant safer but less profitable crops
  - Plant drought-tolerant varieties
  - Do not apply fertilizer
  - Send one family member to migrate to city

Ex-ante smoothing examples for household-producers

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  - Wait until monsoon realization to plant
  - Plant safer but less profitable crops
  - Plant drought-tolerant varieties
  - Do not apply fertilizer
  - Send one family member to migrate to city
- Non-farm enterprises
  - Don't start capital-intensive businesses
  - Limited business re-investment
  - Diversify income sources, lack of specialization
  - Do not adopt new products or technologies

Weather uncertainty and farm investment in India (Rosenzweig & Udry 2013 WP)

- Combine localized annual monsoon forecast data and panel farm investment and production data from India
- Accurate forecasts significantly increase planting-stage investments; no response where forecasts are not accurate
- Use high-accuracy places in IV strategy to trace out potential profits under different investments given rainfall realizations
- Conclude that expected profit-maximizing investment level is 3 times the observed average investment
- Farmers dramatically underinvest!
  - Improving forecast accuracy and access would increase investments and average profits, even if profit variability also increases

Risk and income diversification (Banerjee & Duflo 2007)

Table 6: How the poor earn their money: Occupation

	Percent of Households that own land	Median Ares Of Land Owned	Percent of Households in which At Least One Member: Is Self Employed In: Agriculture	Other	Works for a Wage or Salary in: Agriculture	Other	Percent of HHs That Receive Income From Multiple Sectors
Living on less than $1 a day							
Rural							
Cote d'Ivoire	62.7%	300	37.2%	25.9%	52.4%	78.3%	72.1%
Guatemala	36.7%	29	64.4%	22.6%	31.4%	86.4%	83.8%
India - Udaipur	98.9%	60	98.4%	5.9%	8.5%	90.7%	94.0%
India - UP/Bihar		40	72.1%	40.2%	2.0%	18.9%	41.8%
Indonesia	49.6%	60	49.8%	36.6%	31.1%	34.3%	50.4%
Mexico	4.0%		4.9%	20.4%	2.8%	72.6%	13.2%
Nicaragua	50.4%	280	54.7%	11.6%	0.3%	42.8%	18.4%
Pakistan	30.4%	162	72.1%	35.5%	32.6%	50.8%	66.8%
Panama	85.1%	300	69.1%	17.7%	0.0%	0.0%	19.2%
Peru	65.5%	150	71.7%	25.2%			34.8%
South Africa	1.4%		0.0%	9.1%	27.9%	26.6%	0.4%
Tanzania	92.3%	182					
Timor Leste	95.2%	100	78.5%	12.0%			10.4%

- Income is extremely diverse: lack of specialization
- Small-scale self-employment very common

Ex-post smoothing (Adhvaryu, Kala, & Nyshadham 2021)

Table 4. Does Household Enterprise Activity Respond to Coffee Price Fluctuations?

Open in new tab

	Household owns a business	**Household owns a merchant business**	**Household owns a non-merchant business**	**1(Participation in non-farm self-employment)**
	(1)	**(2)**	**(3)**	**(4)**
Price/SD(Price)	-0.0469***	-0.0388***	-0.0138	-0.0430***
	(0.00978)	(0.0122)	(0.0106)	(0.0109)
Fixed effects		Household, year, and month		
Observations	3,514	3,094	3,094	3,382
Number of households	975	846	846	919
Mean of dependent variable	0.386	0.263	0.242	0.414

Source: Authors' analysis based on data from the Kagera Health and Development Survey (KHDS) and the International Coffee Association.

Outline

What about insurance as a smoothing strategy?

- Insurance protects against 'bad' states of the world
- Realize income Y subject to uncertainty
- Define possible states by s
- In each period, probability π_s of state s
- Price of insurance p_s based on π_s and difference between income in bad state s (Y_s) and desired 'safe' income
- Perfect insurance: get exactly same amount in every period for sure
  - Makes income independent of state
  - If actuarially fair insurance cost, total income after insurance premium $E[Y]$: zero expected profit from insuring

Perfect insurance example

- Two possible states: income in good states is \$100, but 20% chance of bad state with \$0 income
- Insurance product: $\pi_B = 0.2 \Rightarrow p_B = 0.2$ per unit of insurance, pays out 1 unit of income in bad state B
  - Expected profit for insurer is 0
- What is perfect insurance in this situation?

Perfect insurance example

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- Insurance product: $\pi_B = 0.2 \Rightarrow p_B = 0.2$ per unit of insurance, pays out 1 unit of income in bad state B
  - Expected profit for insurer is 0
- Perfect insurance: buy 100 units, premium of \$20 per period
  - Exactly same income every period for sure: no uncertainty
  - Actuarially fair: payout $= E[Y]$

Period	1	2	3	4	5
Income realization	100	0	100	100	100
Premium	-20	-20	-20	-20	-20
Payout	0	100	0	0	0
Total income	80	80	80	80	80

Consumption smoothing vs. insurance

- **Consumption smoothing**: even out consumption by consuming less in good states to create a buffer for bad states
- This form of 'self'-insurance redistributes consumption *across time*
  - Must bear any bad state shock, but can reallocate its impacts across periods to mitigate utility loss
  - Vulnerable to repeated bad states
- **Insurance** allows redistribution *across states*
  - For household-producers: shock realizations have no impact on consumption (or utility)
  - Not vulnerable to repeated bad states

Little formal insurance in developing contexts (Banerjee & Duflo 2007)

Table 11: Market for Insurance and the poor

	Percent of Total Households with Insurance:		
	Any Type	Health	Life
Living on less than $1 a day			
Rural			
Cote d'Ivoire			
Guatemala			
India - Hyderabad			
India - Udaipur			3.8%
India - UP/Bihar	9.2%	4.7%	3.8%
Indonesia	6.0%	3.9%	0.0%
Mexico		50.7%	
Nicaragua	0.0%	5.5%	
Pakistan			
Panama		0.0%	0.0%
Papua New Guinea			
Peru		5.6%	0.0%
South Africa	5.4%		
Tanzania			

Communal insurance

- Stand-in for formal insurance: community members insure each other
  - Still have uncertainty around income shocks, but risk is shared
- Common in many developing contexts
  - Townsend (1994): rejects full insurance in poor villages in India, but finds HH consumption co-moves with village average and does not fully suffer idiosynratic shocks
- Any limitations?

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- Any limitations?
  - Useful for idiosyncratic shocks, less so for common shocks
  - Dependent on relationships, reciprocity $\Rightarrow$ enforcement challenges (limited commitment), potential exclusion of certain households, risk of social strain
  - Transfers may be small and inadequate to fully protect against income losses
  - Moral hazard: potential risk-seeking (effort not observable)
  - Hidden income: avoid social/kin taxes (income not observable)

Outline

Karlan et al (2014) consider: Does risk affect farm investment?

- Consider household-producers with production $F(L, K; A)$
- Even if $\partial F / \partial K$ is big, risk may prevent households from making important production investments
- Why? Why particularly in farming?

Karlan et al (2014) consider: Does risk affect farm investment?

- Consider household-producers with production $F(L, K; A)$
- Even if $\partial F / \partial K$ is big, risk may prevent households from making important production investments
- Why? Why particularly in farming?
  - Want to avoid very low consumption if risky investment fails
  - Communal insurance likely to fail in farming because of serial correlation in agricultural risk
- If we want to understand the role of risk in investment, farming provides some big advantages
  - We can easily measure an important, exogenous part of that risk: weather
  - We can design an insurance product that insures against that risk

Why does this matter?

- Policy: Huge investments from aid community in rural credit/basic income/index insurance
- Academic: Lots of questions around (usually) low demand for index insurance products
  - **Index insurance** provides a payout based on a pre-determined observable threshold (e.g., rainfall levels), rather than individual losses
- Insurance should be very valuable for rainfed agriculture, yet demand is typically quite low
  - Are these products poorly designed?
  - Are farmers making a mistake in some sense, perhaps due to financial literacy? Or recency bias?
  - Or, is there another constraint that prevents farmers from leveraging the gains from insurance?

Model: optimal responses to insurance are not so obvious

Simple setup:

- Farm households start with an endowment Y and live 2 periods. In period 1 they choose
  1. a risky input x_r
  2. a hedging input x_h
  3. a risk-free asset a which offers return $R = 1/\beta$ in period 2
- In period 2 farmers produce $f_s(x_r, x_h$, which equals
  1. $A_G f(x_r)$ in state G
  2. $A_B f(x_h)$ in state B; $A_B < A_G$
- Anticipating the experiment:
  - Farmers receive a cash grant k in period 1
  - Farmers receive state-contingent payout k_s in state s in period 2
- Normalize units so prices of inputs are 1

Farmers solve

$$\max_{\{a, x_r, x_h\}} u(c^0) + \beta \sum_{s \in S} \pi_s u(c_s^1)$$
$$c^0 = Y - x_r - x_h - a + k$$

- With perfect risk pooling and no aggregate risk, $c_G^1 = c_B^1 = c^1$

$$c^1 = \sum_{s \in S} \pi_s (f_s(x_r, x_h) + k_s) + Ra$$

- If credit markets are perfect too, $u'(c^0) = u'(c^1)$

$$u'(c^0) = \beta \pi_G u'(c^1) A_G f'(x_r) = \beta \pi_B u'(c^1) A_B f'(x_h)$$
$$\Rightarrow \pi_G A_G f'(x_r) = 1/\beta = \pi_B A_B f'(x_h)$$

Suppose we can pool risk, but credit markets are imperfect

- Suppose borrowing is not possible: $a \geq 0$
- When the credit constraint binds, $a = 0$ and $u'(c^0) > u'(c^1)$
- FOCs for x_h, x_r are the same
- What is the effect of an upfront cash grant k?

$$u'(c^0) = \beta \pi_G u'(c^1) A_G f'(x_r) = \beta \pi_B u'(c^1) A_B f'(x_h)$$

$$\frac{\partial u'(c^0)}{\partial k} < 0 \Rightarrow$$

$$\beta \pi_G A_G \frac{\partial u'(c^1) f'(x_r)}{\partial k} = \beta \pi_B A_B \frac{\partial u'(c^1) f'(x_h)}{\partial k} < 0$$

$$\Rightarrow \frac{\partial x_r}{\partial k} \text{ and } \frac{\partial x_h}{\partial k} > 0$$

Smoothing across time and space generate surprising effects of insurance

- What is the effect of insurance ($\uparrow k_B$) in this setting?
- $\uparrow k_B \Rightarrow u'(c^1) \downarrow$
  - Because of perfect insurance, $u'(c^1) = u'(c^1_B) = u'(c^1_G)$ so MU decreases in all states of the world
- But, $u'(c^0) = \beta \pi_G u'(c^1) A_G f'(x_r) = \beta \pi_B u'(c^1) A_B f'(x_h) \Rightarrow u'(c^0) \downarrow$
- When $a = 0$, $\downarrow u'(c^0) \Rightarrow x_r, x_h \downarrow$
- When credit constraints bind, insurance *decreases* investment

What if there is imperfect insurance?

- For tractability, now assume perfect credit markets but *no* insurance
- We have $c_s^1 = f_s(x_r, x_h) + k_s + Ra$
- This implies that the farmer's problem is

$$\max_{x_r, x_h, a} u(c^0) + \beta \sum_{s \in S} \pi_s u(c_s^1)$$

$$\max_{x_r, x_h, a} u(Y - x_r - x_h - a + k) + \beta(\pi_G u(A_G f(x_r) + Ra))$$
$$+ \beta(\pi_B u(A_B f(x_h) + k_b + Ra))$$

$$\frac{\partial}{\partial x_r} : u'(c^0) = \beta \pi_G A_G f'(x_r) u'(c_G^1)$$

$$\frac{\partial}{\partial x_h} : u'(c^0) = \beta \pi_B A_B f'(x_h) u'(c_B^1)$$

$$\frac{\partial}{\partial a} : u'(c^0) = \pi_G u'(c_G^1) + \pi_B u'(c_B^1)$$

Solving the farmer's problem

$$\pi_G u'(c_G^1) + \pi_B u'(c_B^1) = \beta \pi_G A_G f'(x_r) u'(c_G^1)$$

$$\pi_B u'(c_B^1) = \pi_G u'(c_G^1)(\frac{1}{R} A_G f'(x_r) - 1)$$

$$\frac{\pi_B u'(c_B^1)}{\pi_G u'(c_G^1)} = \frac{1}{R} A_G f'(x_r) - 1$$

$$R[\frac{\pi_B u'(c_B^1)}{\pi_G u'(c_G^1)} + 1] = A_G f'(x_r)$$

$$R[\frac{\pi_G u'(c_G^1)}{\pi_B u'(c_B^1)} + 1] = A_B f'(x_h)$$

Understanding the solution

$$R[\frac{\pi_B u'(c_B^1)}{\pi_G u'(c_G^1)} + 1] = A_G f'(x_r)$$
$$R[\frac{\pi_G u'(c_G^1)}{\pi_B u'(c_B^1)} + 1] = A_B f'(x_h)$$

- With no insurance, $u'(c_G^1) < u'(c_B^1)$ and $\pi_G + \pi_B = 1$ so that

$$\pi_G A_G f'(x_r) = R[\frac{\pi_B u'(c_B^1)}{u'(c_G^1)} + \pi_G] > R > \pi_B A_B f'(x_h)$$

- Farmers overinvest in hedging inputs relative to the complete markets case, where we had

$$\pi_G A_G f'(x_r) = R = \pi_B A_B f'(x_h)$$

What about farmer responses to cash or insurance?

- Without insurance, you are trying to equilibrate utility today, a chance at a high utility state in the future, and a chance at a low utility state in the future
- This implies $u(c_B^1) < u(c^0) < u(c_G^1)$
- Increasing k_b increases c_B^1, so need to transfer utility to c^0 and $c_G^1 \Rightarrow x_h \downarrow, x_r \uparrow$
- Increasing k increases c^0, but effect depends on assumptions about utility function (absolute risk aversion)
  - e.g., with DARA $\frac{u''(c_B^1)}{u'(c_B^1)} < \frac{u''(c^0)}{u'(c^0)} < \frac{u''(c_G^1)}{u'(c_G^1)}$
  - $\uparrow k \Rightarrow \uparrow a$ and thus consumption in both states in period 1; equilibrating marginal utilities with DARA then implies $x_h \downarrow, x_r \uparrow$

Model predictions

Even in a simple stylized model, predicted responses to credit and insurance interventions in contexts with market failures not obvious

TABLE I

SUMMARY OF IMPLICATIONS OF MARKET IMPERFECTIONS

	Market environment		Predicted change in investment					
	Perfect capital markets	Perfect risk markets	Capital grant treatment only		Insurance grant treatment only		Capital & insurance grant treatment	
			Risky asset	Hedging asset	Risky asset	Hedging asset	Risky asset	Hedging asset
1	Yes	Yes	0	0	0	0	0	0
2	No	Yes	++	++	–	–	+[a]	+[b]
3	Yes	No	+[c]	–[d]	++	– –	++	– –
4	No	No	+	+	–	–	+	+

Notes. [a]The model prediction is ambiguous, but in practice in our experiment the expected value of the insurance treatment was considerably smaller than the value of the cash grant, thus the net predicted effect in our setting is positive. [b]The model prediction is ambiguous, but in practice in our experiment the expected value of the insurance treatment was considerably smaller than the value of the cash grant, thus the net predicted effect in our setting is positive. [c]Small and positive via wealth effect, if DARA; zero if CARA. [d]Small and negative via wealth effect, if DARA; zero if CARA.

Outline

Two questions in this paper

1. What are the returns to capital to farmers?
2. What are the returns to insurance?

- Leads to a straightforward design
  - Some farmers (randomly) receive cash
  - Some farmers (randomly) receive index insurance
  - Some farmers (randomly) receive both
- Note: complicated sampling frame, changes in insurance product over time, discussed in detail in paper

Do farmers want insurance?

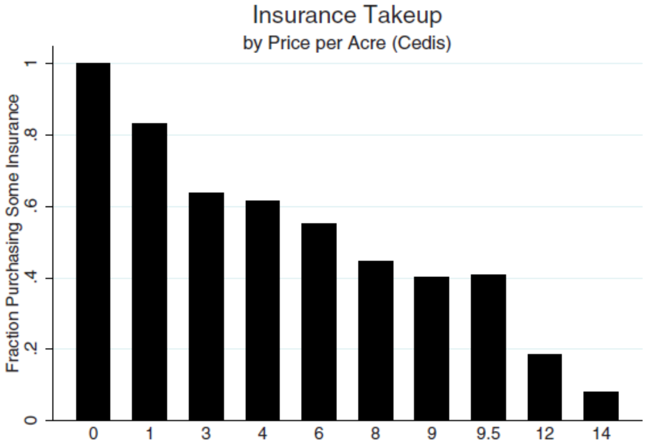


FIGURE II

Higher adoption that in some other contexts: 40-50% for actuarially fair insurance

Demand for insurance coverage

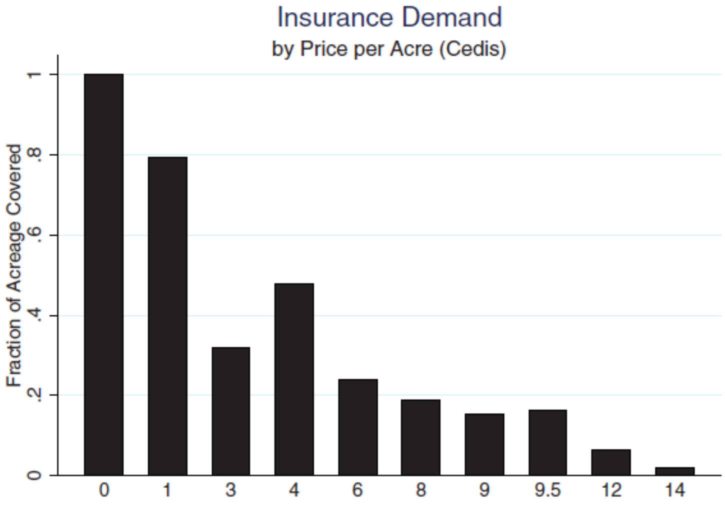
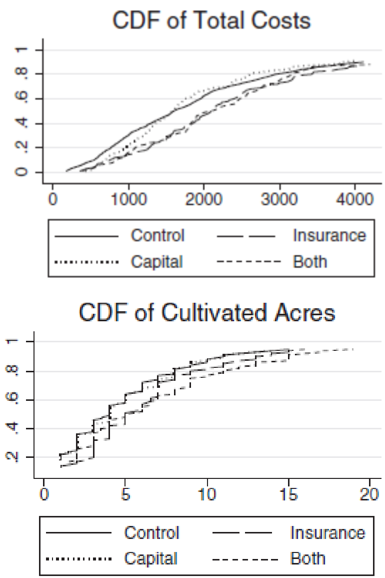


FIGURE III

The Demand for Acres Insured

How do farmers respond to capital and insurance?



Quantifying farmer responses

TABLE IV
IMPACT ON INVESTMENT AND HARVEST (INSTRUMENTAL VARIABLES)

Dependent variable:	(1) Land preparation costs	(2) # of Acres cultivated	(3) Value of chemicals used	(4) Wages paid to hired labor	(5) Opportunity cost of family labor	(6) Total costs	(7) Value of harvest
Insured	25.53**	1.02**	37.90**	83.54	98.16	266.15**	104.27
	(12.064)	(0.420)	(14.854)	(59.623)	(84.349)	(134.229)	(81.198)
Insured * capital grant treatment	15.77	0.26	66.44***	39.76	−52.65	72.14	129.24
	(13.040)	(0.445)	(15.674)	(65.040)	(86.100)	(138.640)	(81.389)
Capital crant treatment	15.36	0.09	55.63***	75.61	−130.56	2.44	64.82
	(13.361)	(0.480)	(17.274)	(68.914)	(92.217)	(148.553)	(89.764)
Constant	169.38***	8.12***	171.70***	201.88***	1,394.58***	2,033.11***	1,417.52***
	(10.603)	(0.399)	(13.804)	(45.383)	(84.786)	(124.294)	(90.635)
Observations	2,320	2,320	2,320	2,320	2,320	2,320	2,320
R-squared	0.017	0.143	0.041	0.005	0.006	0.009	0.012
Mean for control	189.1	5.921	158.3	327.9	1,302	2,058	1,177
Chi^2 test of insured and insured + capital grant treatment	8.889	7.125	36.15	3.136	0.239	5.091	6.618
p-value	.003	.008	.000	.077	.625	.024	.010

Interpreting Farmer Responses

- Limited effects of cash grant only compared to insurance only or both $\Rightarrow$ risk a more important constraint to investment
  - Increases chemical inputs
- Similar effects of insurance only and insurance + cash
  - Increases chemical use and land cultivated: risky input?
  - Combined treatments has additional impact on chemical use
- Liquidity constraints not as binding as assumed (in this context)
  - "When provided with insurance against the primary catastrophic risk they face, farmers are able to find resources to increase expenditure on their farms."

Risky investments?

- If the risk is low rainfall and insurance allows risky investment, should particularly pay off in rainy states

TABLE V

Reallocation of Investments (Instrumental Variables)

Dependent variable:	(1) Value of harvest	(2) Proportion of land planted with maize	(3) Average weekly orchard income	(4) Household has nonfarm income generating activity (binary)	(5) # of HH members working in nonfarm income generating activity	(6) Average weekly enterprise income
Insured	−1,069.13*	0.09***	−1.59*	−0.06*	−0.11*	−8.64
	(596.208)	(0.031)	(0.876)	(0.033)	(0.061)	(7.151)
Insured * capital grant treatment	1,324.48	0.04	0.65	0.07**	0.16**	3.77
	(821.152)	(0.029)	(0.776)	(0.033)	(0.062)	(9.126)
Capital grant treatment	−879.77	0.12***	−0.19	−0.04	−0.08	−2.83
	(642.233)	(0.034)	(0.926)	(0.038)	(0.066)	(4.530)
Insured * total rainfall	156.82**					
	(76.291)					
Insured * capital grant treatment * total rainfall	−155.36					
	(105.649)					
Capital grant treatment * total rainfall	124.95					
	(83.589)					
Total rainfall (hundreds of millimeters)	2,247.39***					
	(624.545)					
Total rainfall squared	−146.65***					
	(40.970)					
Constant	−7,154.76***	0.23***	2.42***	0.17***	0.22***	5.79
	(2,375.086)	(0.016)	(0.613)	(0.027)	(0.038)	(4.363)
Observations	2,320	2,782	2,316	2,320	2,320	2,350
R-squared	0.021	0.090	0.001	0.007	0.010	0.007
Chi^2 test of joint effect of insurance and insurance+capital	0.138	15.52	0.906	0.132	0.388	0.449
p-value	.710	8.16e-05	.341	.717	.534	.503
Mean for control	1177	0.309	2.587	0.261	0.405	6.604

Welfare

TABLE VI
INCOME AND HOUSEHOLD WELFARE (INSTRUMENTAL VARIABLES)

Dependent variable:	(1) Total farm revenue (inc. insurance payouts, net of premiums)	(2) Postharvest assets (livestock + grain)	(3) Household reports having missed a meal in past 12 months (binary)	(4) Total expenditure in 12 months	(5) Utility expenses in past 12 months	(6) School expenses in past 12 months	(7) Borrowed in past 12 months from any source (binary)
Insured	284.98***	530.74**	−0.08**	46.39	0.36	−0.71	−0.00
	(82.991)	(230.839)	(0.033)	(58.767)	(7.102)	(15.872)	(0.025)
Insured * capital grant treatment	109.13	310.66	−0.03	2.44	19.96**	25.83	−0.13***
	(84.446)	(229.150)	(0.030)	(58.568)	(8.444)	(16.111)	(0.033)
Capital grant treatment	66.93	606.12**	−0.08**	7.14	10.30	24.04	−0.06
	(90.585)	(266.636)	(0.037)	(61.540)	(8.268)	(18.841)	(0.040)
Constant	1,386.17***	1,782.29***	0.37***	470.10***	37.72***	107.94***	0.46***
	(91.209)	(223.471)	(0.035)	(43.073)	(5.768)	(12.632)	(0.035)
Observations	2,320	2,265	2,304	2,316	2,316	1,940	3,756
R-squared	0.023	0.007	0.013	0.015	0.050	0.032	0.203
Chi^2 test of joint effect of insurance and insurance + capital	17.97	10.68	9.830	0.581	5.192	1.984	13.39
p-value	0.0000225	0.00108	0.00172	0.446	0.0227	0.159	0.000253
Mean for Control	1,179	1,756	0.229	585.6	41.93	115.2	0.313

Taking stock: several useful lessons

1. Limitation: no real hedging input in the data
    - Would have been useful for testing the model, which is really useful for intuition but was not included in published version of paper
2. Effect of cash grants inconsistent, but does increase input purchases
    - Similar to a range of studies on the impacts of rural credit
    - Will look in a future lecture at impacts of cash/credit on non-farm enterprises
3. Not much additional impact of cash + insurance
    - Suggests credit constraints may not be super important for these households
4. The absence of insurance clearly constrains these farmers
    - Additional analysis on insurance demand in the paper
    - Demand is limited, and strongly depends on varying factors like past payouts
    - Implications for design of insurance products

Outline

Risk and firm production

Risk smoothing

Insurance

Karlan et al (2014) Model

Karlan et al (2014) Empirics

Insurance adoption

Why is adoption of weather insurance low?

- Much research showing low adoption of insurance products, and studying potential factors
  - Liquidity constraints, lack of financial literacy, present bias, lack of trust
  - But adoption remains low even when these barriers are removed in experimental settings (Bridle et al 2018)
- Karlan et al (2014) show higher demand than other studies and clear benefits of providing insurance, but limited demand at actuarially fair price
- Also show that continued use/disadoption depends strongly on whether any payouts are received
  - Adoption challenge for technologies that only infrequently reveal their benefits
  - Related to broader literature on effects of experience on decision-making

Payout effect: Cai, de Janvry, & Sadoulet (2020)

- RCT for weather insurance among rice producing households in China
- Cross-randomize insurance education and subsidy programs
- Analyze insurance adoption two and four years later
- Find "only positive experience with insurance (receiving payouts) increases demand, and that in general this effect does not persist over time."
- Payout effect leads to persistent adoption only with education program; other households "continuously update take-up decisions based on recent experiences"
- Evidence that "stochastic nature of payouts and low level of financial literacy" are key reasons farmer adoption is low

Experience matters for other risk-reducing technologies: Boucher et al (2024)

- RCT in Kenya and Mozambique: communities assigned to control, drought-tolerant seeds, or DT seeds + satellite-based index insurance
  - Objective of boosting farmer resilience and productivity
- DT treatment protects against mid-season drought, mitigates long-term drops in farm investment and productivity following drought exposure
- Bundling index insurance has significant additional impact
- Farmer experience matters:
  - Treated farmers who experience drought and benefit from the treatments increase agricultural investments beyond pre-shock levels
  - Treated farmers who did not experience benefits of the technologies more likely to disadopt them

Addressing basis risk: Feed the Future Innovation Lab for MMR 2025

- Index insurance avoids high cost of verifying individual losses
- Early applications in weather, now more on area yield
- **Basis risk**: possibility farmers experience a loss that should be covered but is not picked up by the index
  - Worsens well-being of insured households, undermines trust
- Potential response: *audit rule* activated when farmers believe index has failed
  - Formally check if conditions meet threshold for payout, issue payout if yes
  - Requires considering of when to trigger audit, how to test conditions outside of regular index procedure
  - Does not reduce importance of accurate index
- Tradeoffs:
  - Will increase costs to insurer $\Rightarrow$ require increased premiums
  - May increase trust and adoption

Takeaways

- Benefits of insurance provision for farm investment, production, and resilience
- But limited adoption of insurance products
- Lessons for product design
  - Subsidies
  - Education
  - Experience
  - Addressing basis risk
- Role of other market failures?
- Role of other behavioral mechanisms?