Agricultural Decisions After Relaxing Credit & Risk Constraints (QJE 2014)

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Motivation

- Agriculture is a key source of income for the global poor
- If poor farmers lack access to credit or sufficient insurance, relaxing these constraints could result in significant investment increases and welfare gains.
- Policy interventions have focused on increasing access to credit, less work on alleviating uninsured risk
- Informal insurance may address some risk, but agriculture faces covariate risks which the community may not be able to adequately insure
- Little research comparing relative importance of missing credit, insurance markets.

Key questions

- Do poor farmers underinvest due to imperfect credit markets, imperfect insurance markets, or both?
- Is there demand for insurance?

Approach and Findings

- Simple model
  - If credit constraints bind, cash grants increase investment and insurance grants decrease investment
  - If risk binds, insurance grants increase investment but cash has minimal effect
- Three-year RCT in northern Ghana offering capital grants and insurance grants
  $\Rightarrow$ Find insurance binds
- Insurance pricing experiment to estimate demand
  $\Rightarrow$There is demand for insurance, even at actuarially fair prices.

Overview

Model

- Two periods, $t = 0$ and $t = 1$
- Two states, $s = \{Good, Bad\}$.
- Standard utility assumptions, $u'(c) > 0$, $u''(c) < 0$
- At $t = 0$, household has wealth Y and chooses investments (x_r, x_h, a) to maximize PDV utility.
- Production $f = f_s(x_r, x_h)$ depends on state at $t = 1$.
    - Higher payoff in good state, $f_G(\boldsymbol{x}) > f_B(\boldsymbol{x})\ \forall \boldsymbol{x}$
    - Risky investment x_r has higher return in good state.
    - Hedging investment x_h has higher return in bad state (but lower return overall).
    - For simplicity, let $\frac{\partial f_B(\boldsymbol{x})}{\partial x_r}\Big|_{s=B} = 0$ and $\frac{\partial f_G(\boldsymbol{x})}{\partial x_h}\Big|_{s=G} = 0$
- a = risk-free (safe) asset, with return $R = \frac{1}{\beta}\ \forall s$ at $t = 1$.

Model

Household Problem:

$$\max_{x_r, x_h, a} u(c^0) + \beta \sum_s u(c_s^1) \quad s.t. \quad c^0 = Y - x_r - x_h - a + k$$

$$c_s^1 = f_s(x_r, x_h) + Ra + k_s \quad \forall s$$

Model

- Perfect credit market – smooth across time

$$u'(c^0) = \beta R \, \mathbb{E}_s u'(c^1)$$

- Perfect insurance market – smooth across states

$$\begin{aligned} c_G^1 = c_B^1 = \bar{c}^1 &= \sum_s \pi_s \left[f_s(\boldsymbol{x}) + Ra + k_s \right] \\ &= \pi_G f_G(\boldsymbol{x}) + \pi_B \left[f_B(\boldsymbol{x}) + k_B \right] + Ra \end{aligned}$$

Perfect credit and insurance markets - Arrow Debreu

- Households can move resources across time and between states to perfectly smooth consumption.

$$c^0 = c^1_G = c^1_B$$

- Investment optimality condition:

$$1 = \beta\pi_G \frac{\partial f_G(\boldsymbol{x})}{\partial x_r} = \beta\pi_B \frac{\partial f_B(\boldsymbol{x})}{\partial x_h}$$

- Separation result - optimal investment decision $\boldsymbol{x} = (x_r, x_h)$ is independent of wealth Y and preferences $u(c)$.
- Adding capital grant K or insurance grant k_B will not affect investment $\boldsymbol{x}$!

Imperfect credit market, perfect insurance

- Impose credit limit $a \geq 0$ and suppose it binds.
  - Under perfect insurance, we still achieve $c_G^1 = c_B^1 = \bar{c}^1$
  - Cannot borrow to fund c^0 or investment, $u'(c^0) > \beta R\, u'(\bar{c}^1)$
- Investment optimality condition:

$$u'(c^0) = \beta \pi_G u'(\bar{c}^1) \frac{\partial f_G(\boldsymbol{x})}{\partial x_r} = \beta \pi_B u'(\bar{c}^1) \frac{\partial f_B(\boldsymbol{x})}{\partial x_h}$$

$$\frac{\partial x_r}{\partial K},\ \frac{\partial x_h}{\partial K} > 0 > \frac{\partial x_r}{\partial k_B},\ \frac{\partial x_h}{\partial k_B},$$

- Capital grant K *increases* all investment
- Insurance grant k_B *decreases* all investment

Perfect credit market, imperfect insurance

- Cannot transfer resources across Good $\leftrightarrow$ Bad states

$$f_G(\boldsymbol{x}) > f_B(\boldsymbol{x})\ \forall \boldsymbol{x} \ \Rightarrow\ c_G^1 > c_B^1$$
$$\Rightarrow\ u'(c_G^1) < u'(c_B^1)$$

- Under perfect credit, we still achieve $u'(c^0) = \mathbb{E}_s u'(c^1)$
- Can rearrange investment optimality conditions to find:

$$\pi_G \frac{\partial f_G(\boldsymbol{x})}{\partial x_r} > R > \pi_B \frac{\partial f_B(\boldsymbol{x})}{\partial x_h}$$

- No insurance $\Rightarrow$ underinvest in risky x_r

Perfect credit market, imperfect insurance (cont'd)

Impact of capital or insurance grant depends on preferences.

- CARA: investment choice independent of wealth
  - $c_G - c_B = f_G(\boldsymbol{x}) - f_B(\boldsymbol{x}) - k_B$
  - K has no effect on x_r or x_h
  - k_B raises c_B directly $\Rightarrow$ increase ratio x_r/x_h to maintain constant gap
- DARA: wealthier is more willing to take on risk
  - $c_G - c_B$ gap increasing in wealth
  - K increases c_G, c_B through investment $\Rightarrow$ increase ratio x_r/x_h
  - k_B raises c_B directly $\Rightarrow$ increase ratio x_r/x_h

Both imperfect

- Binding capital constraint $a = 0 \Rightarrow u'(c^0) > \mathbb{E}_s u'(c_s^1)$
- Binding risk constraint $c_G > c_B$
- K grant $\Rightarrow$ increase both x_r and x_h
- k_B grant raises $\mathbb{E}_s u'(c_s^1) \Rightarrow$ decrease both x_r and x_h
  - increase ratio x_r / x_h

TABLE I

SUMMARY OF IMPLICATIONS OF MARKET IMPERFECTIONS

	Market environment		Predicted change in investment					
			Capital grant treatment only		Insurance grant treatment only		Capital & insurance grant treatment	
	Perfect capital markets	Perfect risk markets	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	+	+	−	−	+	+

Model Prediction

- Can determine which markets are imperfect by focusing on how insurance affects farmers' risky investments
- If insurance increases risky investment, this implies farmers have access to credit but imperfect insurance
- If insurance decreases risky investment, this implies farmers are credit constrained (and may or may not have sufficient insurance).

Experiment setting: Ghana

- Agriculture is 54% GDP. Over half labor force works in agriculture, mainly on smallholder farms.
- Rainfed agriculture – significant weather risk (avg. rainfall 600-900mm/yr)
- Most agricultural investments are risky – cash crops (cocoa), subsistence crops (maize), chemical fertilizer, farm size
- Hedging investments – shifting crop choice (e.g. mango) or move into non-farm work.
- Focus groups cite credit constraints, also acknowledge uninsured risk.

Median Farmer

- Based on Ghana Living Standards Survey 5+ (GLSS5+)
- Household assets
  - $450 livestock
  - $0 cash on hand
  - $0-$430 grain stock (depending on time of year)
- Crop harvest provides $950 income
- Does not use any chemical fertilizer

Experiment design

- Multi-year RCT with smallholder farmers
- Random assignment to 2x2 treatment (4 groups)
  - Y1: cash grant, insurance grant
  - Y2: cash grant, insurance offered at different prices
  - Y3: continue insurance pricing experiment only (no cash)

Control	Insurance
Cash	Insurance & Cash

Experiment design

- Insurance grant design
  - Focus groups: pay when too wet or too dry
  - Rainfall insurance avoids moral hazard
  - 5 rainfall gauges, mean distance 10km from farms
  - Maximum payout = 145/acre, based on GLSS 5+ data on mean yield
- Cash grant $85/acre, averaging $420/farmer
- Follow-up survey on investment expenditures, harvest outcomes, and other household activites

Year 1: Cash Grants and Insurance Grants

- Used GLSS5+ to identify communities in Northern Ghana (region where maize farming common)
- Selected households with farms $\leq$ 15 acres and some maize farming $\Rightarrow$ 502 households
- Randomized treatment assignment at the community level

	Cash grant	No cash
Insurance grant	95 both	135 farms
No insurance	117 farms	155 farms

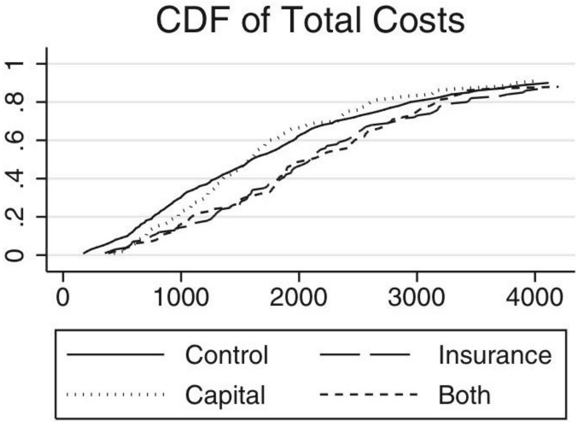
Year 2: Cash Grants and Insurance Pricing Experiment

- Starting in Y2, authors conducted an insurance pricing experiment to estimate demand. Instead of insurance grants, they offered insurance at a range of prices, randomized at the community level.
  - Sample Frame 1: All 502 households from Y1. Offer subsidized insurance to a random subset.
  - Sample Frame 2: 676 additional households from communities that received cash grants in Y1. Offer subsidized insurance to a random subset.
  - Sample Frame 3: 228 households from new communities. All offered insurance, at actuarially fair or commercial prices.
- Cash grants randomly assigned to the households in sample frame 3 only. No overlap with Y1 experiment participants.

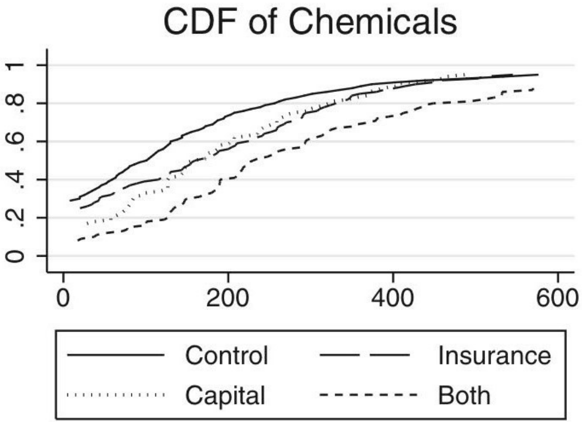
Year 3: Continued Insurance Pricing Experiment

- Continued insurance pricing experiment. No cash grants.
- Partnered with Ghana Agricultural Insurance Programme (GAIP) to market GAIP's comercial drought-indexed insurance product.
- Includes all farmers who were offered insurance in the Y2 pricing experiment, even if they did not purchase before.
- Price randomized at community level
  - subsidy
  - actuarially fair
  - commmercial

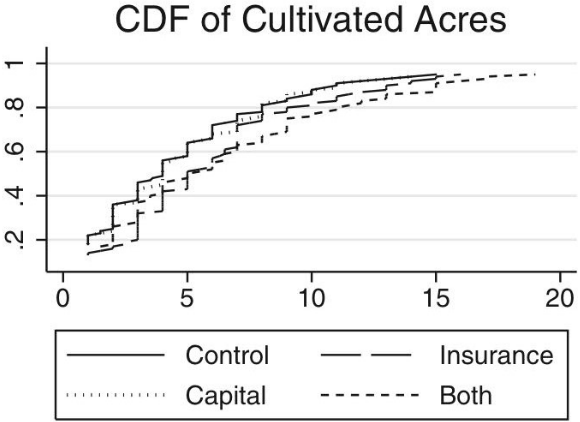
Year 1 Results



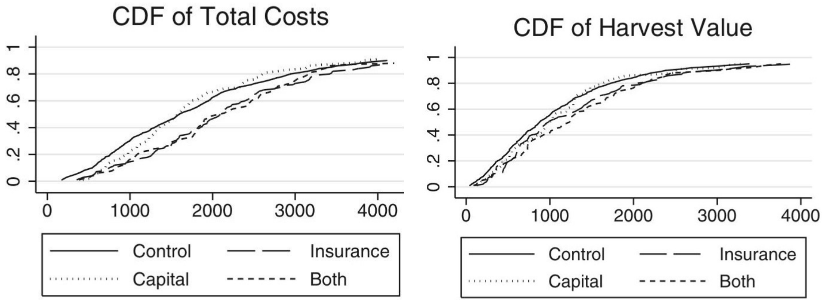
Year 1 Results



Year 1 Results



Year 1 Results



Impact on Investment and Harvest

- Regression equation

$$Y_{it} = \alpha_0 + \alpha_I I_{it} + \alpha_B I_{it} * K_{it} + \alpha_K K_{it} + \alpha X_{it} + \epsilon_{it}$$

- This is the regression analogue to the analysis in Figure I. Table IV (next slide) contains the results.
- Key takeaways:
  - Farmers with rainfall insurance cultivate more acres.
  - Farmers in all treatment groups use more chemical fertilizer, but the capital grant had the biggest impact on this investment.
  - Cannot reject the hypothesis that the increase in harvest value equals the increase in costs.

Impact on Investment and Harvest

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

Notes. Robust standard errors in parentheses. "Insured" instrumented by full set of prices (Table III, column (1) presents first-stage regressions). Total costs (column (6)) includes sum of chemicals, land preparatory costs (e.g., equipment rental but not labor), hired labor, and family labor (valued at gender/community/year-specific wages). Harvest value includes own-produced consumption, valued at community-specific market value. All specifications include controls for full set of sample frame and year interactions. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$.

Balance between risky, hedging investments

- Table V (next slide) examines the riskiness of investment.
- Key takeaways
  - Farmers with rainfall insurance make investment decisions that are more sensitive to rainfall
  - Insured farmers invest more in maize (risky), less in fruits (hedge)

Balance between risky, hedging investments

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 Outcomes

- Table VI (next slide) examines aggregate farm revenue and household welfare outcomes
- Key takeaways
  - There is no statistically significant impact on aggregate household welfare, in terms of direct expenditures
  - Treated households manage shocks better (fewer missed meals)

Welfare Outcomes

TABLE VI

INCOME AND HOUSEHOLD WELFARE (INSTRUMENTAL VARIABLES)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Total farm revenue (inc. insurance payouts, net of premiums)	Postharvest assets (livestock + grain)	Household reports having missed a meal in past 12 months (binary)	Total expenditure in 12 months	Utility expenses in past 12 months	School expenses in past 12 months	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

Notes. Robust standard errors in parentheses. "Insured" instrumented by full set of prices (Table III, column (1) presents first-stage regressions). Column (4), total expenditure, includes the construction or housing improvement, clothing and footwear, ceremonial expenses, community levies, and utilities. All specifications include controls for full set of sample frame and year interactions. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$.

Insurance Pricing Experiment

- Year 1 results suggest credit constraints do not bind
- Starting in Year 2, conduct pricing experiment to estimate demand at different prices
- Theory - what we expect to see
  - With no basis risk, farmers with access to actuarially fair insurance insure fully.
  - Assuming unconstrained credit, positive insurance demand implies the neoclassical separation result

Year 2 Pricing Experiment Results

- Sample Frames 1 & 2 (867 households): subsidized insurance
  - \$1.30/acre (1 GHC) → 85% takeup
  - \$5.25/acre (4 GHC) → 67% takeup
- Sample Frame 3 (228 households): actuarially fair prices and commercial prices
  - \$10.50/acre (8 GHC) → 45% takeup
  - \$12.50/acre (9.5 GHC) → 41% takeup
  - \$15.85/acre (12 GHC) → 18% takeup
  - \$18.50/acre (14 GHC) → 8% takeup

Insurance Takeup

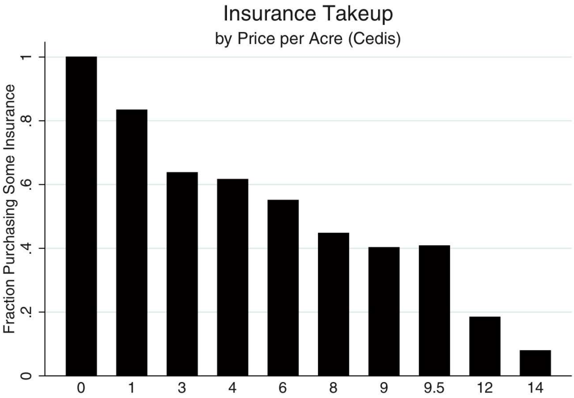


FIGURE II

Insurance Take-up

Includes results from all three sample frames and years.

Insurance Demand

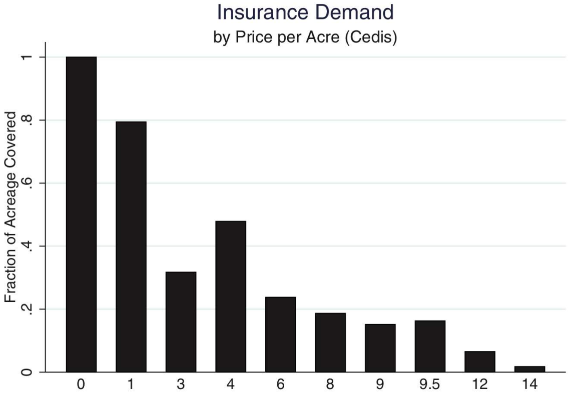


FIGURE III

The Demand for Acres Insured

Includes results from all three sample frames and years.

Interpreting the Demand Curve

- There is a demand for insurance, even at actuarially fair prices (GHC 6-9.5).
- Higher demand at GHC 1 and 4?
  - Higher demand from households who received cash grants in either Y1 or Y2.
  - Surprising! A capital grant should not increase insurance demand, regardless of preferences.
  - Potential explanations: NGO effect (reciprocation), or increased trust (if received or saw payouts in Y1)

Other factors

- Selection effect: At high prices, only the most risk averse farmers purchase insurance.
  - Investment behavior changes with increasing price, hard to characterize more thoroughly from this experiment.
- Basis risk and mistrust reduce take up
  - Experience increases trust
  - Tension between offering insurance that pays out frequently (increase trust/take up) and offering insurance that covers large, infrequent risks

Critiques

- Interventions increase investment expenditures, but they may not pay off. Higher harvest value does not exceed higher expenditures (Figure 1).
- Why encourage greater cultivation of maize, a risky subsistence crop? Why not encourage farmers to switch to cash crops like cocoa?
- Total cost calculation includes opportunity cost of family labor, but there may not be a viable outside option.

Conclusion and Policy Implications

- Risk constraints bind
- Agricultural credit assistance in isolation may not increase investment
- Subsidized insurance can result in greater increases in investment compared to cash grants, at lower cost
- There is demand for insurance, even at actuarially fair prices
- Consider offering standalone insurance, rather than just bundled with credit
- Trust matters; partnering with existing, respected institutions like microcredit organizations or NGOs may increase demand