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Risks and farmers' investment in productive assets in Nigeria

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Risks and farmers' investment in productive assets in Nigeria

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1. Background issue

- Significant role of **informal insurance** in rural sub-Saharan Africa <= high cost of formal insurance (Hazell 1992), lack of ex-post risk mitigation policy (Yamauchi et al. 2009)
- Different options for informal insurance

Traditional cropping system (Mixed cropping etc) **Consumption smoothing** **Remittances**	**Investment into productive assets** **• Land** **• Livestock**	**Investment into productive assets** **• irrigation pump** **• milling machine**
Risk reduction – great But also low return	High return, but limited risk reduction due to tenure insecurity, livestock disease etc	High return, and significant risk reduction - Dual roles

- Productive assets like irrigation pump, milling machine may play **dual roles**

	Irrigation pump	**Milling machine**
Raise productivity	Yield increase Value of product	Value of product
Reduce risk	Drought or poorly distributed rains	Crop price fluctuations

Our hypotheses

- In an environment with low productivity and higher rainfall risks, the capital injection increases the likelihood of irrigation pump investments
- In an environment with low productivity and higher risks to the price of gari, the capital injection increases the likelihood of milling machine investments

2. Descriptive statistics

We use dataset collected for the evaluation of the Second National Fadama Development Project (Fadama II) in Nigeria. Detail descriptions of the dataset are in Nkonya et al. (2008).

	Total	% who invested in 2006	
		Milling machine	Irrigation pump
Total	3758	3.2	6.9
Fadama II member	1281	6.7	16.5
Fadama II neighbor	1224	0.0	1.6
Non-Fadama II LGA	1253	2.3	2.4
Male	2629	2.1	8.3
Female	1124	5.1	3.8
Owner of milling machine before 2006	167	5.4	
Owner of irrigation pump before 2006	257		26.8

	All	Milling machine investors in 2006	Irrigation pump investors in 2006
Household size	9	9	10
Age	42	45	45
Years of education	6	6	6
Monthly household expenditure in 2005 (US$)	239	383	234
Total value of assets in 2005 (US$)	1575	1575	2472
Distance to nearest town in 2005 (km)	4	4	4
Distance to nearest all-weather road in 2005 (km)	3	4	2

3. Conceptual framework (Definitions of symbols are in the paper)

$$\max_{P_t, M_t, c_{kt}} E_t \left[\sum_{t=0}^{\infty} \delta^t U(c_{kt}; z_t) \right] \quad (1)$$

Expected utility

subject to

$$\pi_{ft} s_{ft} + \pi_{gt} s_{gt} + \pi_{ct} s_{ct} + \Pi_t S_t + T_t + W_t - P_t w_{pt}(1 - F \cdot f_p) - M_t w_{mt}(1 - F \cdot f_m) - \sum N_t w_{nt}(1 - F \cdot f_n) \geq 0 \quad \text{for all } t = 0, \ldots, \infty \quad (2)$$

$$P_t w_{pt} \cdot f_p + M_t w_{mt} \cdot f_m + \sum N_t w_{nt} \cdot f_n \leq f^* \quad \text{if } F = 1 \text{ for all } t = 0, \ldots, \infty \quad (3)$$

$$W_{t+1} = W_t + \pi_{ft} s_{ft} + \pi_{gt} s_{gt} + \pi_{ct} s_{ct} + \Pi_t S_t + T_t - P_t w_{pt}(1 - F \cdot f_p) - M_t w_{mt}(1 - F \cdot f_m) - \sum N_t w_{nt}(1 - F \cdot f_n) \geq 0 \quad (4)$$

Liquidity constraint

$$q_{kt} - x_{kt} + A_{kt} - s_{kt} - c_{kt} \geq 0 \quad \text{for all } k = 1 \ldots K; t = 0, \ldots, \infty \quad (5)$$

Physical constrains

$$G(q_t, x_t, P_t, M_t, r_t; \psi_t) = 0 \quad \text{for all } k = 1 \ldots K; t = 0, \ldots, \infty \quad (6)$$

Production technology

$$\begin{pmatrix} r_t \\ \pi_{gt} \end{pmatrix} \sim H\left(\begin{pmatrix} \mu_r \\ \mu_g \end{pmatrix}, \begin{pmatrix} \sigma_r^2 & \rho_{rg} \\ \rho_{rg} & \sigma_g^2 \end{pmatrix} \right) \quad \text{for all } t = 0, \ldots, \infty \quad (7)$$

Joint distribution of rainfall and price

$$\text{rainfall risk } (\theta_r) = \frac{\sigma_r}{\mu_r}, \qquad \text{gari price risk } (\theta_g) = \frac{\sigma_g}{\mu_g} \quad (8)$$

Coefficient of variation as measurement of risk

$$c_{kt}, q_{kt}, x_{kt} \geq 0 \quad \text{for all } k = 1 \ldots K; t = 0, \ldots, \infty, \quad (9)$$

Indirect utility function from Bellman's equation

$$E[V_t(z_t, T_t, W_t, A_{kt}, F, f_p, f_m, f_n, f^*, w_{pt}, w_{mt}, w_{nt}, \pi_{ft}, \pi_{gt}, \pi_{ct}, \Pi_t, \psi_t, r_t, \mu_g, \sigma_g, \mu_r, \sigma_r, \rho_{rg}, \delta)] = \max_{P_t, M_t, c_{kt}} \left\{ \int\int U(c_{kt}; z_t) \cdot h(r, \pi_g)\, dr\, d\pi_g + \delta \cdot \int\int V_{t+1}(P_t, M_t, N_t, z_{t+1}, T_{t+1}, W_{t+1}, A_{k,t+t}, F, f_p, f_m, f_n, f^*, w_{p,t+1}, w_{m,t+1}, w_{n,t+1}, \pi_{g,t+1}, \pi_{f,t+1}, \pi_{c,t+1}, \Pi_{t+1}, \psi_{t+1}, r_{t+1}) \cdot h(r, \pi_g)\, dr\, d\pi_g \right\}, \quad (10)$$

$$\partial\{E[V_t \mid P_t = 1, F = 1)] - E[V_t \mid P_t = 0, F = 1)]\}/\partial\theta_r > 0 \text{ and} \quad (13)$$

$$\partial\{E[V_t \mid M_t = 1, F = 1)] - E[V_t \mid M_t = 0, F = 1)]\}/\partial\theta_g > 0. \quad (14)$$

Empirical hypotheses

$$\partial[\text{Probability}(M_t = 1 \mid F = 1)]/\partial\theta_g > 0$$

- Probability of investment into milling machine at t ($M_t = 1$) under external capital injection ($F = 1$) increases as price risk of un-milled products (θ_g) increases

$$\partial[\text{Probability}(P_t = 1 \mid F = 1)]/\partial\theta_r > 0$$

- Probability of investment into milling machine at t ($M_t = 1$) under external capital injection ($F = 1$) increases as price risk of un-milled products (θ_g) increases

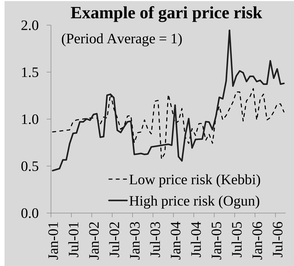
4. Empirical results and policy implications

Empirical method

- **Instrumental variable Diff-in-Diff**
- **Stratified PSM**
  - Stratification of states based on risk levels
  - PSM for each strata

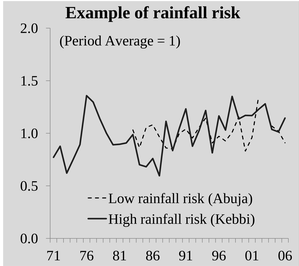
  <= combining the matching based on covariates and propensity score can significantly reduce the bias (Dehejia & Wahba 1999; Stuart & Rubin 2008)

Example of gari price risk



Source: NBS (2007)

Example of rainfall risk



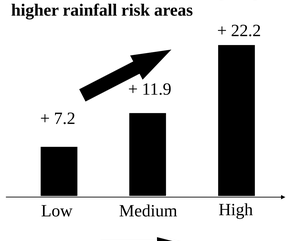
Source: NIMET (2009)

Stratified Propensity Score Matching

	Reference city	Rainfall risk		White gari monthly price (Jan 01 – Sep 05)	
		Coefficient of variation	Group	Coefficient of variation	Group
Adamawa	Yola	0.333	High	0.205	Low
Bauchi	Bauchi	0.166	Medium	0.213	Low
Gombe	Bauchi	0.166	Medium	0.234	Low
Imo	Owerri	0.128	Low	0.241	Low
Kaduna	Kaduna	0.120	Low	0.257	High
Kebbi	Sokoto	0.209	High	0.240	Low
FCT	Abuja	0.095	Low	0.260	High
Lagos	Ikeja	0.165	Medium	0.259	High
Niger	Minna	0.140	Low	0.284	High
Ogun	Ijebu Ode	0.150	Medium	0.323	High
Oyo	Ibadan	0.201	High	0.297	High
Taraba	Yola	0.333	High	0.227	Low

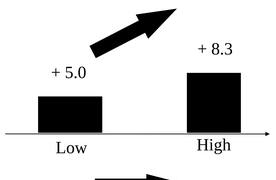
Source: Oyekale (2009) for rainfall in Adamawa and Taraba , NBS (2007) and NIMET (2009) for others.

More demand for irrigation pump in higher rainfall risk areas



Fadama II increased probability of investment in irrigation pump by
- 22.2 percentage points in high rainfall risk areas
- 11.9 percentage points in medium risk areas
- 7.2 percentage points in low rainfall risk areas

More demand for milling machines in higher *gari* (unmilled cassava) price risk areas



Fadama II increased probability of investment in milling machine by
- 8.3 percentage points in high price risk areas
- 5.0 percentage points in low price risk areas

Source: Presenters' calculations

Two stage least squares

	Milling machine		Irrigation pump	
	OLS	2SLS	OLS	2SLS
Fadama II participation (yes =1)	.060***	.044	.160***	.110*
Fadama*Rainfall risk	-.065	.236	.454***	1.529*
Fadama*Price risk	.571*	1.177	1.569***	2.218
Eligible*gender	.029***	.028***	-.077***	-.078***
Eligible*years of education	-.001**	-.001*	-.001	-.001
Eligible*state 3	.018	.035	-.033**	.020
Eligible*state 4	-.009	.016	-.036**	.047
Eligible*state 5	-.006	.010	.101***	.168***
Eligible*state 6	-.035***	-.026	.207***	.233***
Eligible*state 7	.109	-.125*	.021	.110
Eligible*state 8	-.030	-.021	-.002	.042
Eligible*state 9	-.052	-.046	-.075***	-.025
Eligible*state 10	-.005	-.013	.050**	-.080
Eligible*state 11	.007	-.001	.009	.021
Eligible*state 12	.014	.009	-.065***	-.099***
Intercept	.009***	.009***	.027***	.021***
R-square	.074	.074	.163	.142
p-value (overall fit)	.000	.000	.000	.000
p-value (no endogeneity - Hausman)		.988		.042
p-value (weak identification)		.000		.000
p-value (no overidentification)		.497		.225
Observation	3192	3182	3192	3182

***: 1% **: 5% *: 10%

Instrumental variables

Eligibility
Eligibility × household size
Eligibility × rainfall risk × household size
Eligibility × rainfall risk × education
Eligibility × price risk × age
Eligibility × age of respondent
Eligibility × rainfall risk × age
Eligibility × price risk × household size
Eligibility × price risk × education

2SLS also supports results in stratified PSM
- External financial project (Fadama II project) → Probability of investment ↑
- Rainfall risk ↑ → Impact of Fadama II on irrigation pump investment ↑
- Price risk ↑ → Impact of Fadama II on milling machine investment ↑

Conclusions

1. **Some productive assets play dual roles, raising productivity, and mitigating the risks**
   - Irrigation pump and milling machines can both raise productivity of land and labor, and reduce the impacts of weather and market related risks
2. **Impact of financial capital injection should be evaluated not only on the income growth, but the benefit from reduced exposure to risks**
   - Financial support for productive asset investments should be evaluated not only on productivity growth but also reduced exposures to risks by beneficiary famrers

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