Self-Protection from Weather Risk using Improved Maize Varieties or Off-farm Income and the Propensity for Insurance

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Background & Motivation

- High income fluctuation due to weather shocks
- Missing and underdeveloped financial markets
  - Farmers lack access to formal insurance and reinsurance
- Non profit maximizing technology and informal risk management
- Resources for risk management over last decades
  - Improved (drought tolerant) maize varieties (IMV)
  - Weather index insurance
- Studies report significant gains in adoption of IMV
- Low demand and under insurance in pilot programs:
  - 5%-10% of households purchased insurance
  - Demand lowest amongst the most risk averse households
  - Wealthy households more likely to purchase insurance

Background & Objectives

- Disappointing uptake and performance of weather index insurance have been linked to:
  - Poor understanding and lack of trust for the insurance instrument
  - Cash and credit constraints
  - Mismatch between insurance payouts and actual losses due to basis risk
  - Insurance coverage not competitive with pre-existing informal insurance from risk-sharing networks
- Investigate self-protection practices (adoption of IVM & off-farm income diversification) on risk premium & propensity for insurance

Background & Motivation

- Self-protection are actions which reduces the probability of being in a low wealth state at the expense of reducing wealth in all other states, e.g.
  - Car/house alarm against theft
  - Use of improved (drought tolerant) maize varieties against drought
  - Income source diversification
- Formal insurance transfer wealth from high utility state to a low utility state
- Adopting of IMV and off-farm income directly or indirectly affects the shape of yields distributions, thus the probability of crop failure

Theoretical framework

- Falco & Chavas (2009): mean-variance-skewness risk premium framework
- This study: mean-variance-skewness-kurtosis risk premium framework
- Estimate& test flexible moment-based production function based on expanded form of the Johnson S_U family distribution
- Use estimates to simulate how changes in the share of land under IMV and off-farm income influence risk premiums
  - Examine interact effect of adoption of IMV with low and high application of inorganic fertilizer
  - Examine interact effect of off-farm income under high and low supply of farm labor
  - Estimate elasticities in each scenario

Theoretical framework

$$y = F(x_1, x_2, v), \quad x_2 = g(I) \tag{1}$$

$$c_2 \leq p_1(y - c_1) + I \tag{2}$$

$$\underset{c_1, x_1, x_2}{\text{Maximize}} \quad E[U(c_1, p_1(F(x_1, x_2, v) - c_1) + I)] \tag{3}$$

Taking $\pi = p_1 F(x_1, x_2, v) + I$ & $CE = E(\pi) - R$,

$$U(c_1, CE - p_1 c_1) = E[U(c_1, \pi - p_1 c_1)] \tag{4}$$

$$R = \frac{1}{2} r_2 E[\pi - E(\pi)]^2 + \frac{1}{6} r_3 E[\pi - E(\pi)]^3 + \frac{1}{24} r_4 E[\pi - E(\pi)]^4 \tag{5}$$

I = off-farm income; v = error; c_2 = numeraire bundle, price=$p_2 = 1$; c_1 = yield consumed; $y - c_1$ = yield marketed; price=p_1; $r_2 = -\frac{U''(.)}{U'(.)}$, $r_3 = -\frac{U'''(.)}{U'(.)}$, $r_4 = -\frac{U''''(.)}{U'(.)}$

Theoretical framework

$$Y_k = \mathbf{X_k}\beta + \frac{[(\frac{\sigma_k^2}{G(\theta,\mu)})^{\frac{1}{2}}(sinh(\theta Z_k) - F(\theta,\mu))]}{\theta}, Z_k \sim N(\mu, 1) \quad (6)$$

$F(\theta,\mu) = exp(\frac{\theta^2}{2})sinh(\theta\mu)$,
$G(\theta,\mu) = \frac{(exp(\theta^2)-1)(exp(\theta^2)cosh(-2\theta\mu)+1)}{2\theta^2}$

$$\sigma_k^2 = \sigma_0^2 + \sigma_1^2(\mathbf{X_k}\beta) \quad (7)$$

$$\theta = \theta_0 + \theta_1(\mathbf{X_k}\beta) \quad (8)$$

M1-Heterogenous nonnormal (Full model): $\mu, \theta_0, \theta_1, \sigma_0 \& \sigma_1 \neq 0$
M2-Homogenous nonnormal: $\mu \approx 0, \theta_0, \theta_1, \sigma_0 \neq 0$ & $\sigma_1 = 0$
M3-Heterogenous nonnormal: $\mu \approx 0, \theta_0, \theta_1, \sigma_0 \& \sigma_1 \neq 0$
M4-Homogenous nonnormal: $\mu \approx 0, \theta_0, \sigma_0 \neq 0$ & $\theta_1, \sigma_1 = 0$
M5-Homogenous normal: $\mu \approx 0, \theta_0 = \theta_1 = \sigma_1 = 0$, $\sigma_0 \neq 0$
M6-Heterogenous normal: $\mu \approx 0, \theta_0 = \theta_1 = 0$ & $\sigma_0, \sigma_1 \neq 0$

Table 1: Data summary (N=516)

Variable	Definition	Mean	Std.Dev.	Min	Max
Land	Area (hectares) planted	0.456	0.550	0.02	5
Land squared	Area (hectares) planted squared	0.510	1.815	0.0004	25
Labor	Number of labor days used	222.726	250.616	0	1567
Improved seeds	Dummy for IMV	0.335	0.473	0	1
Inorganic fertilizer	Dummy inorganic fertilizer	0.031	0.174	0	1
Organic fertilizer	Dummy organic fertilizer use	0.037	0.188	0	1
Gentle slope	Share of land flat or gentle slope	0.733	0.372	0	1
Fertility	Share of fertile land	0.597	0.440	0	1
Erosion	Share of land under erosion	0.190	0.372	0	1
Improved seeds x Organic fertilizer	Interaction between Improved seeds and Organic fertilizer	0.012	0.107	0	1
Value of seeds	Amount spent on the purchase of seeds in Uganda Shillings (x 10^3)	22.336	35.660	0.6	400
Off-farm income	Income generated from non-farm activities in Uganda Shillings (x 10^5)	9.544	58.864	0	1230
Improved seeds x Value of seeds	Interaction between improved seeds and Value of seeds	11.944	32.778	0	400
Improved seeds x Inorganic fertilizer	Interaction between improved seeds and inorganic fertilizer	0.021	0.145	0	1
Off-farm income x labor	Interaction between off-farm income and labor	1603.645	8424.786	0	161280
Age	Average age of household members 9 to 81 years supplying labor	28.750	9.145	14.833	78
Yield	Corn yield in kg/hectares	360.992	255.394	5	1000

Table 2: OLS estimates of mean yield effect

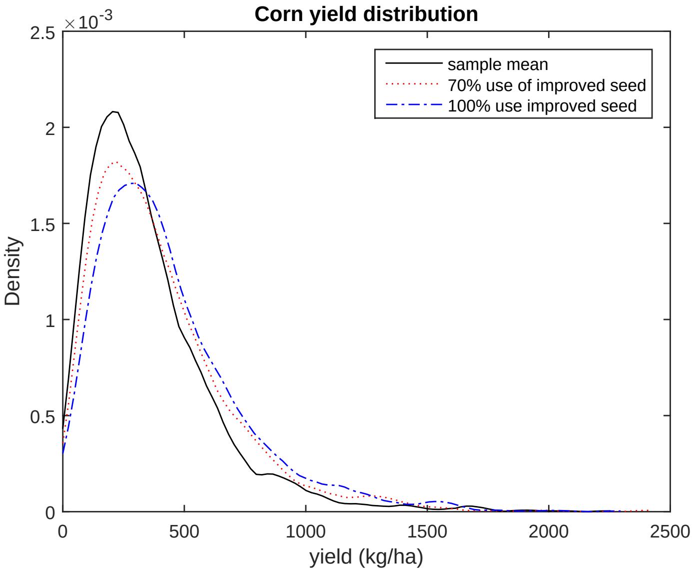
	OLS			OLS-Robust	
Variable	Coef.	Std. Err.	$P > \|t\|$	Std. Err.	$P > \|t\|$
Land	-54.505	27.223	0.046	27.426	0.047
Land squared	33.745	25.552	0.187	27.408	0.219
Labor	9.2495	13.469	0.493	13.412	0.491
Improved seed	42.485	14.127	0.003	14.426	0.003
Inorg. fertilizer	33.279	21.092	0.115	19.148	0.083
Org. fertilizer	-12.341	14.673	0.401	9.722	0.205
Gentle slope	-3.9912	11.574	0.730	12.024	0.740
Fertility	-16.167	11.44	0.158	12.122	0.183
Erosion	.8573	11.260	0.939	11.027	0.938
Improved seed X Org. fertilizer	8.9327	14.245	0.531	13.097	0.496
Value of seed	22.932	21.286	0.282	31.866	0.472
Off-farm income	50.213	15.844	0.002	10.747	0.000
Improved seed X Value of seed	-13.570	22.949	0.555	30.438	0.656
Improved seed X Inorg. fertilizer	-30.712	21.104	0.146	19.229	0.111
Off-farm income X Labor	-21.155	15.905	0.184	13.448	0.116
Age	-10.017	11.194	0.371	10.311	0.332
constant	360.99	10.982	0.000	10.982	0.000

R-squared $= 0.0755$

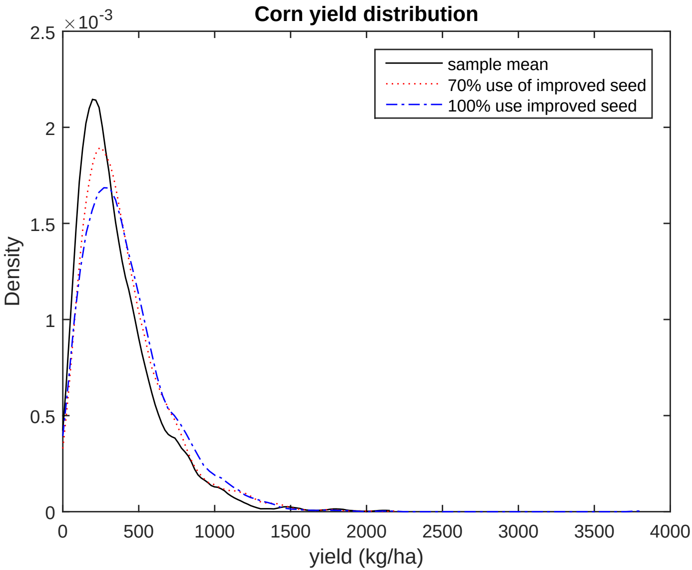
Table 3: Method of moment estimates using Johnson *SU*

Variables	$M1$	$M2$	$M3$	$M4$	$M5$	$M6$
Constant	359.37	349.98	366.28	356.08	360.99	366.61
Land	-67.96	-73.74	-59.73	-50.13	-55.41	-38.27
Land squared	38.44	39.81	33.98	30.25	34.55	27.82
Labor	15.55	-1.86	16.46	7.54	9.03	2.43
Improved seeds	43.77	44.79	38.97	22.49	42.44	39.09
Inorg. fertilizer	30.52	34.50	31.40	15.49	33.04	31.61
Org. fertilizer	-4.92	-1.12	-3.60	-0.33	-12.14	-16.52
Gentle slope	-9.48	-12.58	-5.92	-5.41	-3.96	-3.13
Fertility	-7.69	-6.77	-8.16	-3.83	-16.11	-14.45
Erosion	-4.05	-2.24	-3.48	-5.31	0.49	0.79
Improved seeds X Org. fertilizer	-4.54	-5.33	0.00	3.57	8.71	1.72
Value of seeds	14.28	12.52	8.03	2.17	22.60	69.93
Off-farm income	64.63	46.37	80.85	51.26	50.20	111.78
Improved seeds X Value of seeds	-2.60	-0.58	-0.00	-4.33	-13.24	-47.78
Improved seeds X Inorg. fertilizer	-25.38	-29.67	-28.44	-13.92	-30.48	-36.59
Off-farm income X Labor	-19.00	-23.23	-28.09	-17.70	-21.07	45.00
Age	-8.43	-8.08	-7.86	-4.44	-10.03	-4.02
σ_0^2	158.15	187.31	113.80	269.78	245.32	83.05
σ_1^2	0.32	/	0.48	/	/	0.45
θ_0	1.09	0.89	0.60	0.55	/	/
μ	10.75	11.72	11.20	15.59	/	/
θ_1	-0.15	-0.17	/	/	/	/
LLH	-3507.92	-3560.17	-3511.55	-3516.74	-3571.50	-3565.42
AIC	7059.84	7162.34	7065.09	7073.48	7179.00	7168.83
BIC	6878.42	6989.17	6891.92	6908.56	7030.57	7012.16

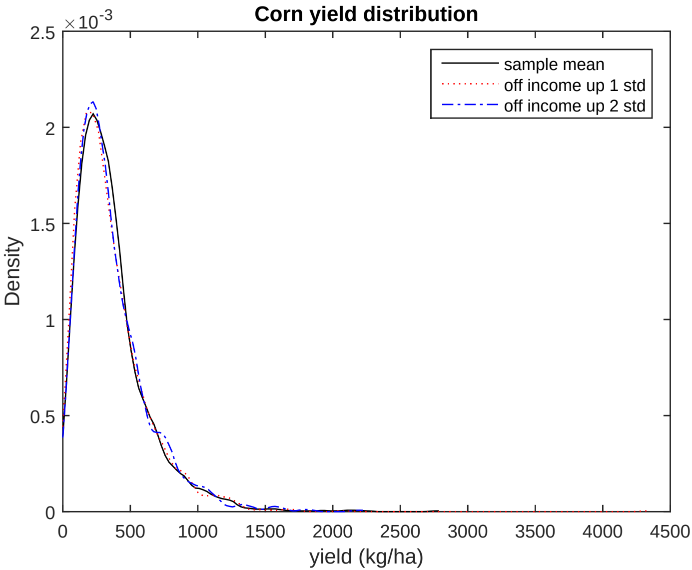
Yield density for infertile-Flat-NoErosion soil



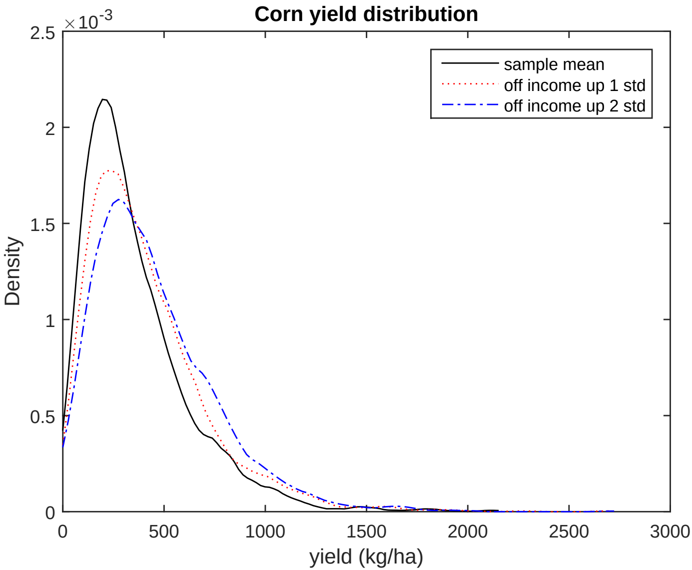
Yield density for Fertile-Flat-NoErosion soil



Yield density for infertile-Flat-NoErosion soil



Yield density for Fertile-Flat-NoErosion soil



IMV: fertile (fig. 3.6, 3.7) & infertile soil (fig. 4.6, 4.7)

Fig. 3.6: Effect on risk premium-Variance component

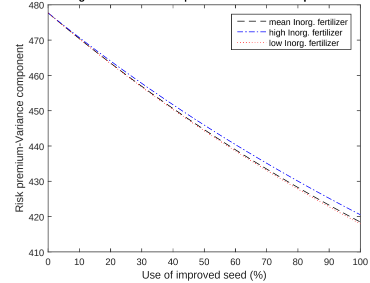


Fig. 4.6: Effect on risk premium-Variance component

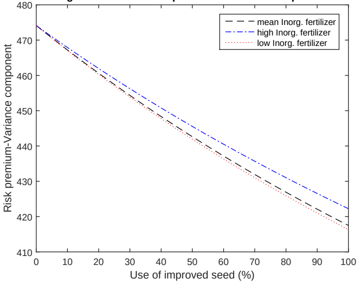


Fig. 3.7: Effect on risk premium-skewness component

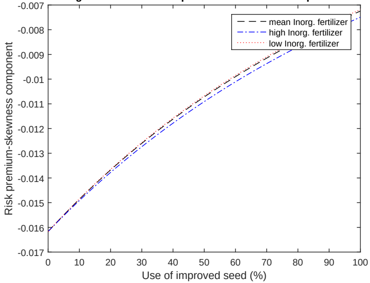
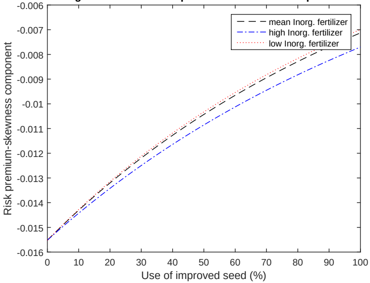
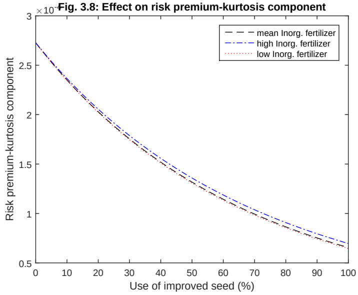
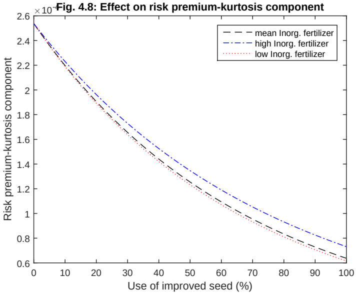


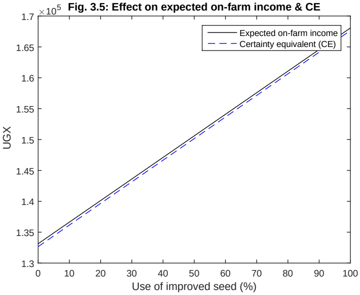
Fig. 4.7: Effect on risk premium-skewness component

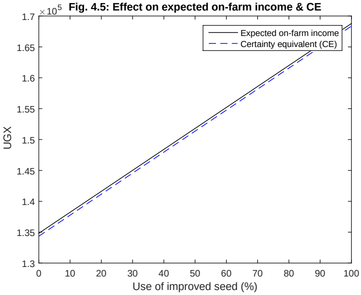


IMV: fertile (fig. 5.6, 5.7) & infertile (fig. 6.6, 6.7)









IMV elasticity of risk premium

- Fertile-Flat-NoErosion plots
  - -1.251 at sample mean
  - -1.38 high inorganic fertilizer
  - -1.12 low inorganic fertilizer
- Infertile-Flat-NoErosion plots
  - -1.31 at sample mean
  - -1.68 high inorganic fertilizer
  - -1.12 low inorganic fertilizer
- Considering skewness but not kurtosis overstate skewness risk premiums by 1.21% to 1.54%

Off-farm Income elasticity of risk premium

- Fertile-Flat-NoErosion plots
  - -1.47 at sample mean
  - -1.68 high labor supply
  - -1.07 low labor supply
- Infertile-Flat-NoErosion plots
  - -2.70 at sample mean
  - -2.80 high labor supply
  - -2.61 low labor supply
- Considering skewness but not kurtosis overstate skewness risk premiums by 1.50% to 2.42%

Conclusion

- Adoption of IMV and off farm income reduces risk premiums
- Effect of IMV on risk premium stronger on infertile than fertile land
- Effect of IMV on risk premium even stronger with low fertilizer use
- Self-protection practices crowd out insurance if design cover risk layers covered by the practices

THANK YOU

Questions???