Basis Risk and Demand for Index-Based Livestock Insurance: Evidence from Northern Kenya

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Motivation

- Pilot index insurance projects have experienced extremely low uptake (often less than 5%) and low levels of demand among those that purchase.

- Potential factors of low demand:
  - Price
  - Non-price factors: e.g., understanding of the product, trust, informal insurance
  - Basis risk

- In the IBLI Marsabit case we are in the unique position to observe household level losses and design error in a product specifically designed to minimize basis risk.

> "Given the central role played by basis risk in determining benefits of and demand for index insurance, at least some modest efforts should be made to assess its magnitude." Miranda & Farrin, 2012, p422

Decomposing Risk

- Let $L_{i,d,t}$ represent the losses of individual *i* in division *d* at time period t.
  - Division is any unit used to define the covariate range.

- $\bar{L}_{d,t}$ is the division average losses in time period *t.*

(1)
$$L_{i,d,t} = L_{i,d,t} - \bar{L}_{d,t} + \bar{L}_{d,t}$$
$$Covariate\ Losses_{d,t} = \bar{L}_{d,t}$$
$$Idiosycratic\ Losses_{i} = L_{i,d,t} - \bar{L}_{d,t}$$

(2)
$$Var_t[L_{i,d,t}] = Var_t[\bar{L}_{d,t}] + Var_t[L_{i,d,t} - \bar{L}_{d,t}] + 2Cov_t[L_{i,d,t} - \bar{L}_{d,t}, \bar{L}_{d,t}]$$
$$Covariate\ Risk_{d} = Var_t[\bar{L}_{d,t}]$$
$$Idiosyncratic\ Risk_{i,} = Var_t[L_{i,d,t} - \bar{L}_{d,t}]$$

Index Insurance and Basis Risk I

- Index insurance uses a signal to predict and indemnify covariate losses as predicted by the index, ideally leaving just the idiosyncratic component.

(3) $Basis\ Risk_{\mathrm{i},d} = \sout{\mathrm{Covariate}\ Risk_{d}} + \mathrm{Idiosycratic}\ Risk_{\mathrm{i},d} + 2Cov_{t}\left[L_{\mathrm{i,d},t} - \bar{L}_{\mathrm{d},t}, \bar{L}_{\mathrm{d},t}\right]$

- But in practice the prediction ($Index_{d,t}$) and covariate losses are not identical:

$$\bar{L}_{d,t} \neq Index_{d,t}$$

- The difference between predicted and covariate losses is called design error and the variance of that difference is design risk.

(4) $Design\ Risk_{d} = Var_{t}\left[\bar{L}_{\mathrm{d},t} - Index_{\mathrm{d},t}\right]$

Index Insurance and Basis Risk II

- Risk if uninsured:

$$Var_t[L_{i,d,t}] = Var_t[\bar{L}_{d,t}] + Var_t[L_{i,d,t} - \bar{L}_{d,t}] + 2Cov_t[L_{i,d,t} - \bar{L}_{d,t}, \bar{L}_{d,t}]$$

- Risk with index insurance (Basis Risk):

$$Var_t[L_{i,d,t} - Index_{d,t}] = Var_t[\bar{L}_{d,t} - Index_{d,t}] + Var_t[L_{i,d,t} - \bar{L}_{d,t}] + 2Cov[L_{i,d,t} - \bar{L}_{d,t}, \bar{L}_{d,t} - Index_{d,t}]$$

- Risk w/o II $\overset{?}{\underset{<}{>}}$ Risk w/II: the hypothesis that index insurance reduces risk exposure turns on the basis and design risk of the contract. We know surprisingly little empirically about this issue.

IBLI Contract in Marsabit, Kenya

- *The signal:* Normalized Difference Vegetation Index (NDVI) collected by satellite
- *Response function:* constructed by regressing historic livestock mortality onto variants of historic cumulative standardized NDVI (*Czndvi*) data.
- *Indemnity payments*: made using predictions of livestock mortality according to:

$$max\left[index_{d,t}(\bar{L}_{d,t},\mu_{d,t}) - 0.15, 0\right] * value\ of\ livestock\ insured$$

Figure 1. Temporal Structure of IBLI contract

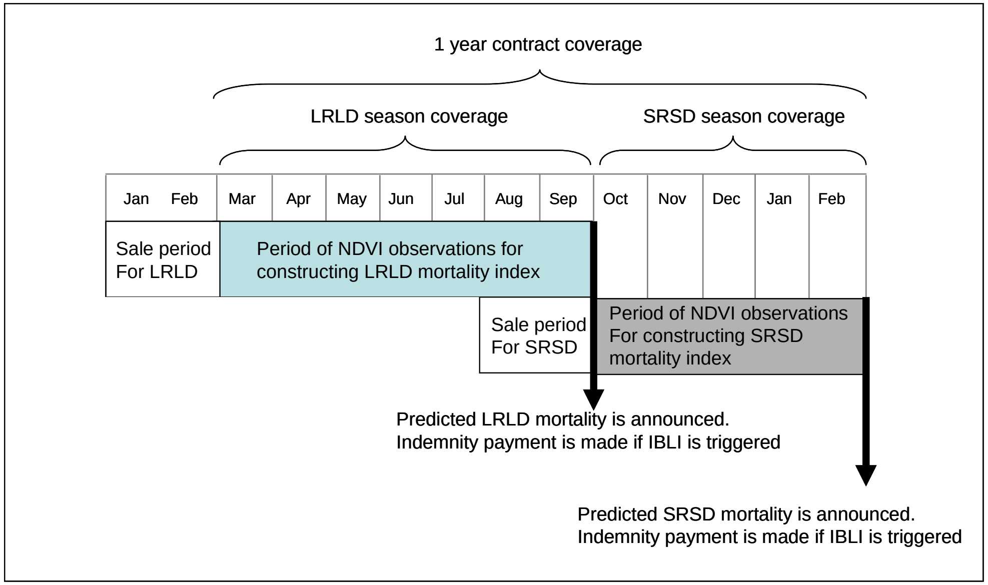
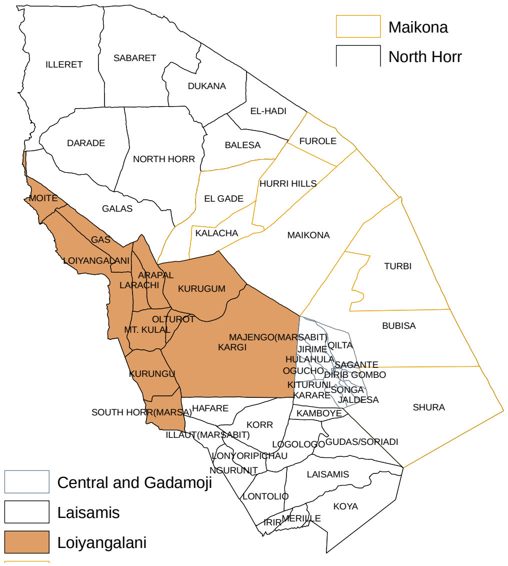


Figure 2. IBLI Geographical Coverage



IBLI Sales & Household Survey

924 households in Marsabit region, Kenya

- Extensive demographic, economic, and herding data
- Baseline survey collected in Oct & Nov 2009
- Three annual follow-up surveys (~4% attrition per survey)

Table 1. Representation of demand for IBLI in the survey sample

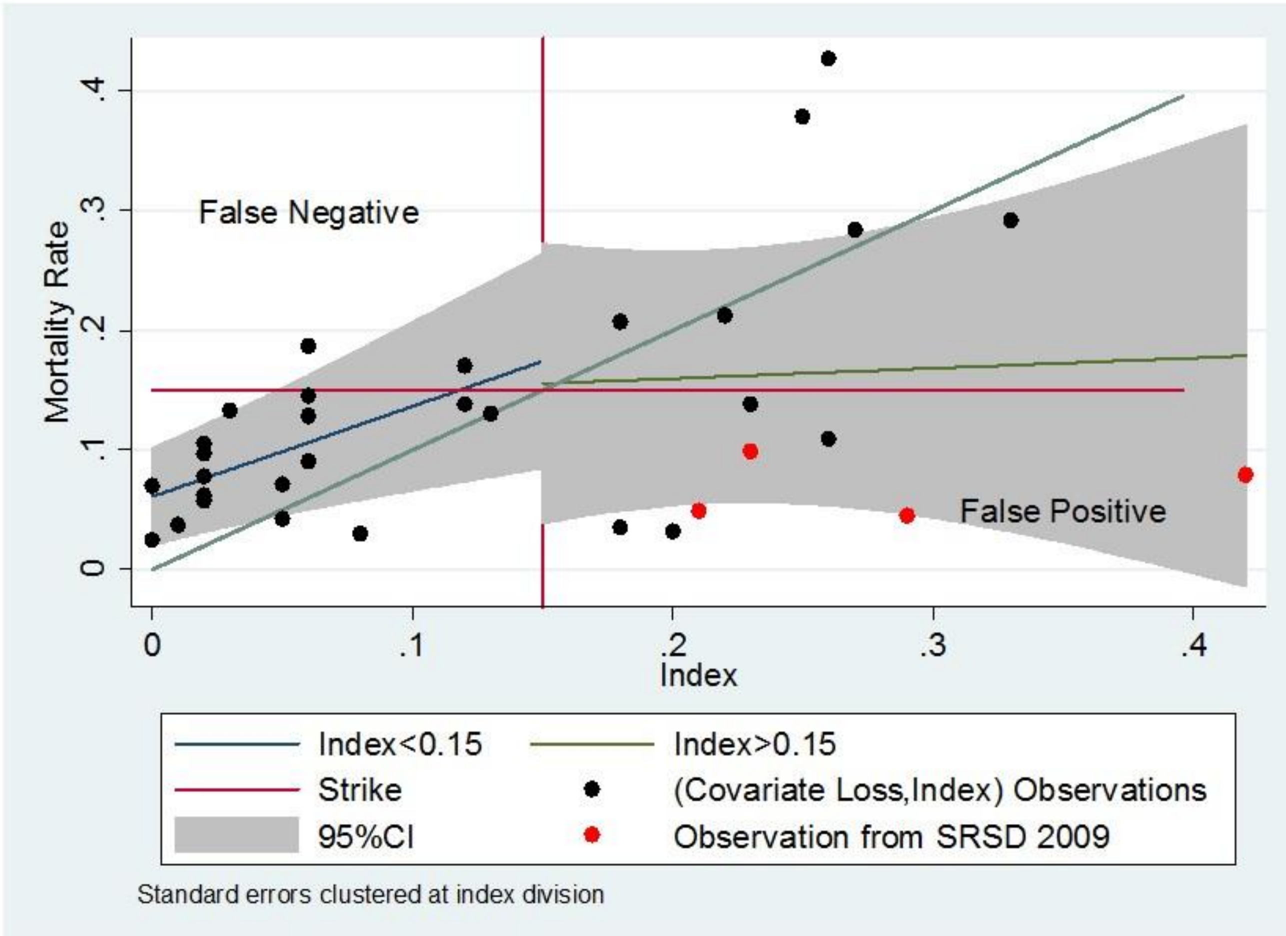
Survey Round	Sales Window	Insurance Season		Marsabit Sales	IBLI Survey Households: No Purchase	IBLI Survey Households: Purchased	IBLI Survey Households: Ever Purchased
R1							
	J-F 2010	LRLD10	(N)	1,974	664	256	256
			(Mean)[&]	(3.0)	-	(3.76)	
	A-S 2010[#]	SRSD10	(N)	-	-	-	256
R2			(Mean)[&]	-	-	-	
	J-f 2011	LRLD11	(N)	595	790	134	313
			(Mean)[&]	(2.1)	-	(3.07)	
	A-S 2011	SRSD11	(N)	509	797	127	382
R3			(Mean)[&]	(1.6)	-	(2.39)	
	J-F 2012[#]	LRLD12	(N)	-	-	-	
			(Mean)[&]	-	-	-	
	A-S 2012	SRSD12	(N)	216	844	80	397
R4			(Mean)[&]	(1.9)	-	(2.68)	

Notes: Jan/Feb 2010, Jan/Feb 2011 & Aug/Sept 2011 were sold under UAP. Aug/Sept 2012 was sold under APA.

[&] Mean TLU is the mean coverage in terms of TLUs covered conditional on purchasing IBLI.

[#] There were no sales during the Aug/Sept 2010 and Jan/Feb 2011 sales periods due to supply channel failures.

Design Risk Above & Below Strike



$$\bar{L}_{d,t} = \begin{Bmatrix} \alpha^1 + \beta^1 Index_{d,t} + \varepsilon_{i,d,t} & if\, Index_{d,t} < 0.15 \\ \alpha^2 + \beta^2 Index_{d,t} + \varepsilon_{i,d,t} & if\, Index_{d,t} \geq 0.15 \end{Bmatrix}$$

Table 2. Covariate livestock mortality (% TLUs) and design error, in total and conditional on seasonal division covariate losses $(\bar{L}_{\mathrm{d},t})$ greater than 15%.

	Central/Gada		**Laisamis**		**Loiyangalani**		**Maikona**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Covariate Losses (%)	15.84	15.72	12.63	8.66	12.83	5.67	9.21	8.29
$\lvert \bar{L}_{\mathrm{d},t} \geq 15\%$	40.24	3.43	24.79	5.07	18.80	1.84	29.14	-
Design Error	1.34	10.43	-1.50	9.83	0.21	13.11	-3.79	14.07
$\lvert \bar{L}_{\mathrm{d},t} \geq 15\%$	14.74	2.73	0.29	1.53	6.79	5.23	-3.86	-
Risk	719.2	433.6	419.3	345.0	363.6	328.8	322.3	366.1
$\lvert \bar{L}_{d,t} \geq 15\%$	414.3	324.2	209.6	230.8	177.4	206.7	151.9	240.4
Idiosyncratic Risk	472.0	365.8	344.3	292.7	331.4	309.0	253.6	309.1
$\lvert \bar{L}_{\mathrm{d},t} \geq 15\%$	242.4	189.5	163.6	156.6	161.2	174.9	95.1	125.4
Covariate Risk:	247.1	-	75.1	-	32.3	-	68.7	-
$\lvert \bar{L}_{d,t} \geq 15\%$	171.8	-	46.0	-	16.2	-	56.7	-
Design Risk	108.9	-	96.6	-	171.9	-	197.9	-
$\lvert \bar{L}_{d,t} \geq 15\%$	52.3		1.3		26.4		0.0	
Observations	1255		800		1937		1736	

Incidence of $\bar{L}_{\mathrm{d},t}$>15% out of 8 possible seasons: Central/Gadamoji (2), Laisami (3), Loiyangalani (3), Maikona (1).

Table 3. Accuracy: Covariate livestock mortality (% TLUs) and design risk, in total and conditional on seasonal division covariate losses $(\bar{L}_{d,t})$ greater than 15%.

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Incidence of $\bar{L}_{d,t}$>15% out of 8 possible seasons: Central/Gadamoji (2), Laisami (3), Loiyangalani (3), Maikona (1).

Conditional values are calculated by $\frac{1}{7}\sum_{\bar{x}\geq 15}(x-\bar{x})^2 \ where\ \bar{x}=\frac{1}{8}\sum_{t=1}^{8} x \ and\ x=\{L_{idt}, L_{idt}-\bar{L}_{dt}, \bar{L}_{dt}, index_{dt}\}$.

Table 4. Potential & Accuracy: Covariate livestock mortality (% TLUs) risk and basis risk, in total and conditional on seasonal division covariate losses $(\bar{L}_{d,t})$ greater than 15%.

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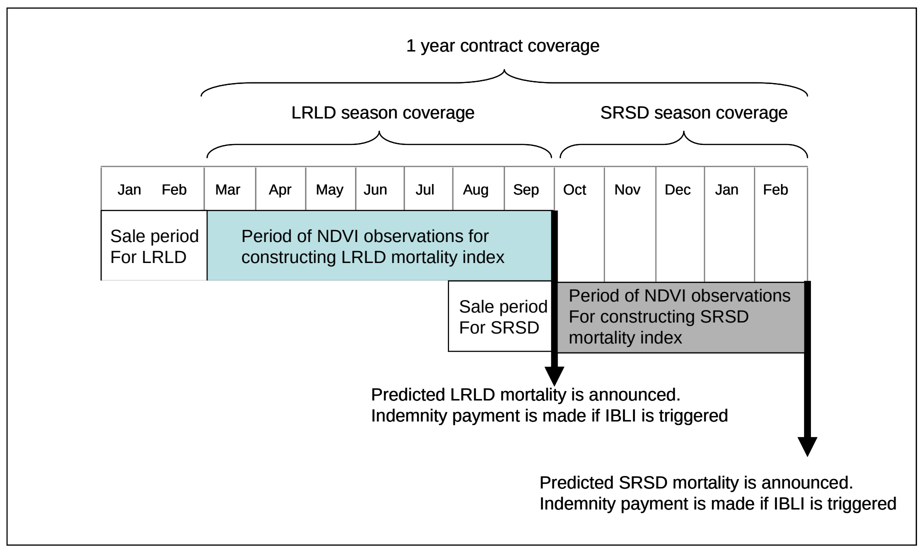
Observed Design Risk

- Households only observe the index values of those seasons during which coverage existed.

Table 5. Cumulative observed design error

Sales season	Central/Gadamoji	Laisamis	Loiyangalani	Maikona
LRLD 2010	0.000	0.000	0.000	0.000
LRLD2011	0.024	0.076	0.085	0.027
SRSD 2011	0.093	0.162	0.212	0.085
SRSD 2012	0.168	-0.015	0.289	0.076

Sales Season	Observations
J-F 2010	-
J-f 2011	LRLD10
A-S 2011	LRLD10, SRSD10
A-S 2012	LRLD10, SRSD10, LRLD11



Hausman-Taylor estimates of the binary and continuous purchase decisions

Price, Knowledge & Livelihood		Purchased IBLI, (N=711)		Ln(TLUs insured), (N=461)	
		Coefficient	St. Er.[4]	Coefficient	St. Er.[4]
TV Exogenous	Received Discount Coupon	0.079***	-0.025	-0.024	-0.113
	Ln(IBLI Price/TLU)	-0.093**	-0.040	-0.241**	-0.120
	Pre-Czndvi	0.000	-0.001	0.003	-0.003
	Observed Design Error	-0.387***	-0.114	-0.461	-0.335
TV Endogenous	Ln(monthly income)	0.010*	-0.006	0.007	-0.021
	% income from livestock	-0.110***	-0.039	-0.181	-0.113
	Herd size	0.003**	-0.001	-0.011	-0.010
	Herds size^2	-0.00001*	0.000	0.000	0.000
	HSNP (Participant=1)	-0.005	-0.024	0.135	-0.103
	# of Social Groups	-0.013	-0.014	-0.075*	-0.039
	IBLE Knowledge	0.056***	-0.008	-0.017	-0.026
	# of IBLI Sources	0.024**	-0.010	0.052**	-0.024
TI Exogenous	Risk Moderate	-0.011	-0.063	-0.001	-0.166
	Risk Adverse	-0.104	-0.083	-0.325	-0.294
	Division Mean Covariate Loss	-2.833	-3.172	-2.312	-5.622
	Covariate Risk	-2.874	-9.216	14.126	-25.781
TI Endogenous	Financial Literacy	0.039	-0.290	0.508	-0.781
	Average Idiosyncratic Losses	2.530	-6.547	16.659	-11.951
	Idiosyncratic Risk	13.168	-13.391	-2.062	-25.487
	Cov(IL,CL)	-5.451	-42.896	-30.101	-120.873
	Constant	0.604	-0.590	2.686	-1.733

Additional covariates include: age of head, gender of head, max education, asset index, asset index squared, savings, transfers given, transfers received, participation in the IBLI game, and living in an HSNP community. Standard errors are clustered at the household level. *** p<0.01, ** p<0.05, * p<0.1

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Interpretation of Results

- Many households would still face a significant portion of their original risk even with ILBI coverage.
- Households continue to experiment with IBLI. Those that experiment reflect many of the characteristics that have been found to be factors of demand in other studies but most of those factors do not impact how much coverage is purchased.
- Idiosyncratic and design risk were unable to account for the low levels of demand although observed design risk does reduce willingness to experiment.

Thank you