

How Basis Risk and Spatiotemporal Adverse Selection Influence Demand for Index Insurance: Evidence from Northern Kenya

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WHY INDEX INSURANCE?

Uninsured risk is believed to be a key barrier to the economic growth of many agricultural households in low income countries.

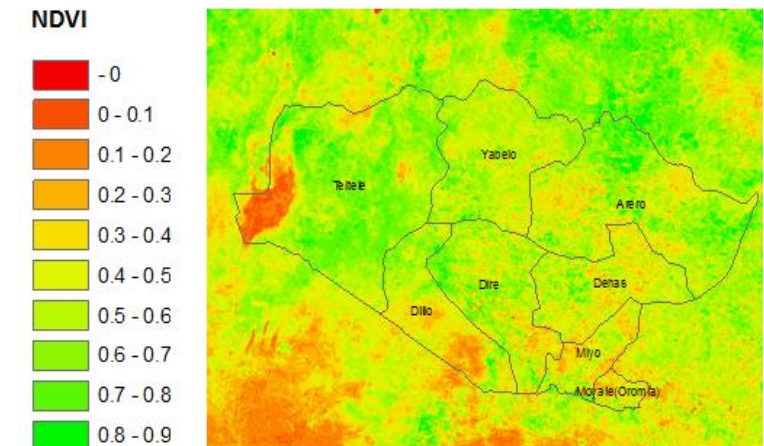
Conventional insurance provides coverage for individual losses but requires a great deal of costly information

- Data on individual historic risk for actuarial calculations
- Monitoring for moral hazard and adverse selection
- Client specific claims calculations and validation require site visits

Index insurance provides coverage for covariate losses based on an exogenous signal correlated with average losses (e.g., yield samples, precipitation)

- Data on historic signal values for actuarial calculations
- Obviates moral hazard and cross-sectional adverse selection
- Claims calculations are done remotely with no need for site visits

But, index insurance leaves households facing basis risk



MOTIVATION:

Although index insurance is thought to provide access to a valuable financial tool, uptake in developing countries has generally been extremely low (often less than 5%), as have coverage levels among those that purchase.

We have learned that:

- Demand is price sensitive
- Non-price factors—such as trust, product understanding, liquidity, access to alternatives—are at least as important as price
- Basis risk is likely to reduce demand and proxies for basis risk supported such claims

But, demand remains mostly unexplained

To what extent can estimates of basis risk and information on potential adverse selection contribute to our understanding of demand for index insurance?

Cai, de Janvry & Sadoulet 2011; Cole et al. 2013; Dercon et al. 2014; Giné, Townsend & Vickery 2008; Hill, Robles & Ceballos 2013; Karlen, Osie & Udry 2013; Mobarak & Rosenzweig 2012; Takahashi et al. 2014

SETTING: PASTORALISTS IN MARSABIT, KENYA

Pastoralists

- Highly dependent on livestock for their income (43% depend fully on livestock in our data)
- Droughts are periodic and the largest cause of livestock mortality (62% in our data)

Index Based Livestock Insurance (IBLI)

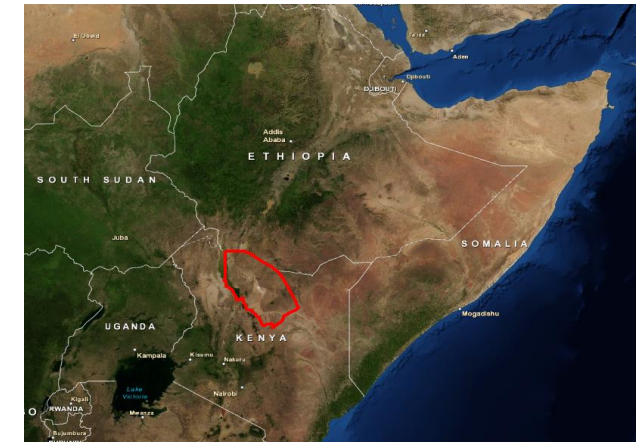
- Launched in January, 2010
- The IBLI index uses remotely sensed NDVI to predict area-average livestock mortality rates

There is potential for adverse selection

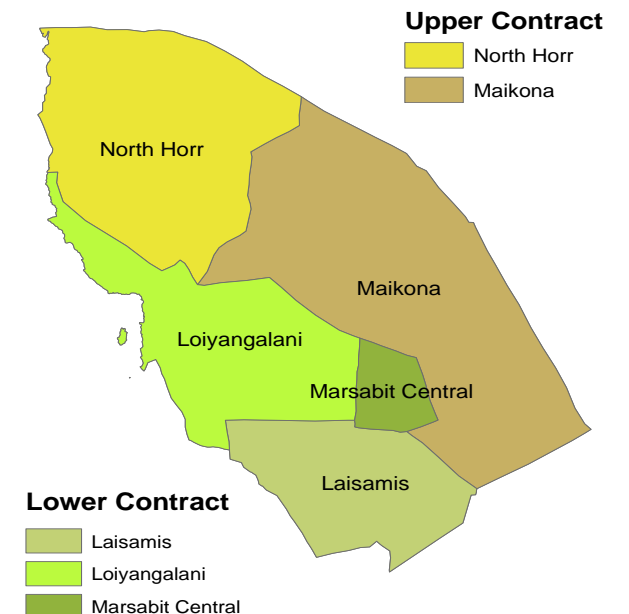
- Spatial: Index divisions were lumped into larger premium divisions
- Temporal: Households may have information on upcoming conditions, exacerbated by the timescale of rangeland degradation and livestock mortality

Basis risk is substantial (Jensen, Barrett & Mude 2014)

- Households face a great deal of idiosyncratic risk
- The IBLI index is imperfect (design risk is non-trivial)



Source: Esri



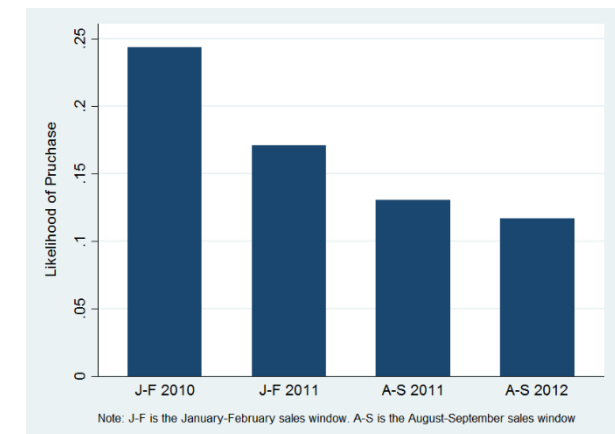
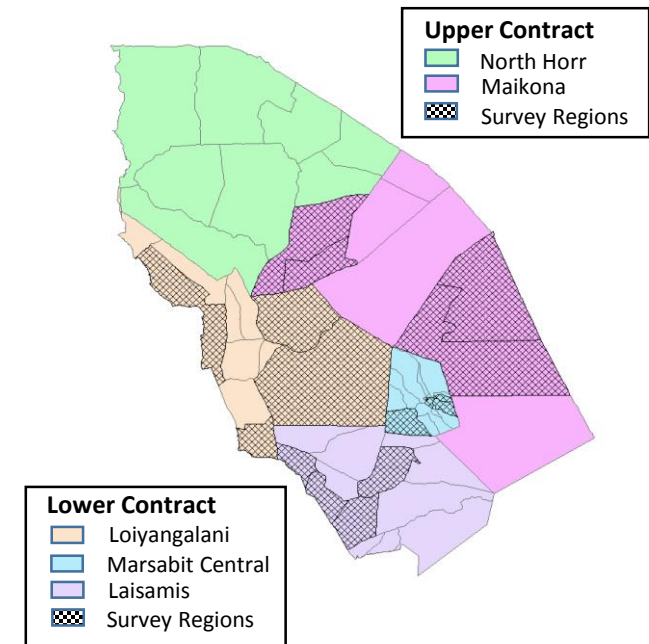
RESEARCH DESIGN & DATA

Survey data

- 4 rounds of an annual longitudinal survey of 924 households
- 4/5 IBLI index divisions
- Seasonal data collected for the most relevant variables
- Attrition rates < 4% between rounds

Research Design

- Randomized distribution of coupons providing 10-60% premium discounts to 60% of sample each sales window
- Randomized IBLI education to ½ of sample HHs in 9 of 16 communities
- Overlap with a cash transfer program (HSNP) in 8 of 16 communities



EMPIRICAL STRATEGY: HECKMAN SELECTION MODEL

Demand includes a selection process:

- $y_{i,t}$ = observed demand
- $y_{i,t}^*$ = unobserved underlying demand
- $h_{i,t}^*$ = unobserved desirability
- c_i, d_i = time invariant household characteristics
- $x_{i,t}$ = time invariant household characteristics
- $z_{i,t}$ = $x_{i,t}$, discount coupon dummy
- $u_{i,t}, v_{i,t}$ = errors

$$y_{it} = \begin{cases} 0 & \text{if } h_{it}^* \leq 0 \\ c_i + x'_{it}\beta + u_{it} & \text{if } h_{it}^* > 0 \end{cases}$$

$$y_{it}^* = c_i + x'_{it}\beta + u_{it}$$

$$h_{it}^* = d_i + z'_{it}\gamma + v_{it}$$

1. Pooled:

$$c_i = c, d_i = d$$

2. Conditional independence:

(Wooldridge 1995 & Mundlak 1978)

$$c_i = \bar{x}_i^{FE'} \gamma_1 + e_{it}^c, \quad e_{it}^c | \bar{x}_i^{FE} \sim N(0, \sigma_e^2)$$

$$d_i = \bar{x}_i^{FE'} \delta_1 + e_{it}^d, \quad e_{it}^d | \bar{x}_i^{FE} \sim N(0, \sigma_e^2)$$

$$\bar{x}_i^{FE} = \frac{1}{T} \sum_T x_{it}^{FE}, \quad x_{it}^{FE} \subseteq x_{it}, z_{it}$$

KEY VARIABLES

Prospective Adverse Selection:	
Expected conditions $_{i,d,t}$	= Respondent's prediction of coming season's rangeland conditions (Good, Normal, Bad)
Pre-CZNDVI $_{d,t}$	= Preceding season's cumulative standardized normalized differenced vegetation index
Division Livestock Mortality $_d$	= Division average <i>Covariate Losses</i> $_{d,t}$
Division Risk $_d$	= Division average variance $_{i,d}$ (<i>Losses</i> $_{i,d,t}$)
Division Correlation $_d$	= Division average correlation $_{i,d}$ (<i>Losses</i> $_{i,d,t}$, <i>Covariate Losses</i> $_{d,t}$)
Basis Risk Related Characteristics:	
Correlation $_{i,d}$	= Correlation $_{i,d}$ (<i>Losses</i> $_{i,d,t}$, <i>Covariate Losses</i> $_{d,t}$)
Observed Design Error (ODE) $_{d,t}$	= $\frac{1}{k} \sum_k \text{Covariate losses}_{d,k} - \text{index}_{d,k}, k = 1, \dots, t - 2$
Randomized Interventions:	
Effective Price $_{i,d,t}$	= $\ln(\text{premium}_{d,t} - \text{discount}_{i,d,t})$
Coupon Dummy $_{i,d,t}$	= 1 if household received a coupon (excluded variable)
Extension Game $_{i,d}$	= 1 if households participated in IBLI education game in Dec/Jan '09/'10 (increases test scores on IBLI knowledge by ~30%)

Notes: Losses are rates. i=individual, d=index division, t=sales window

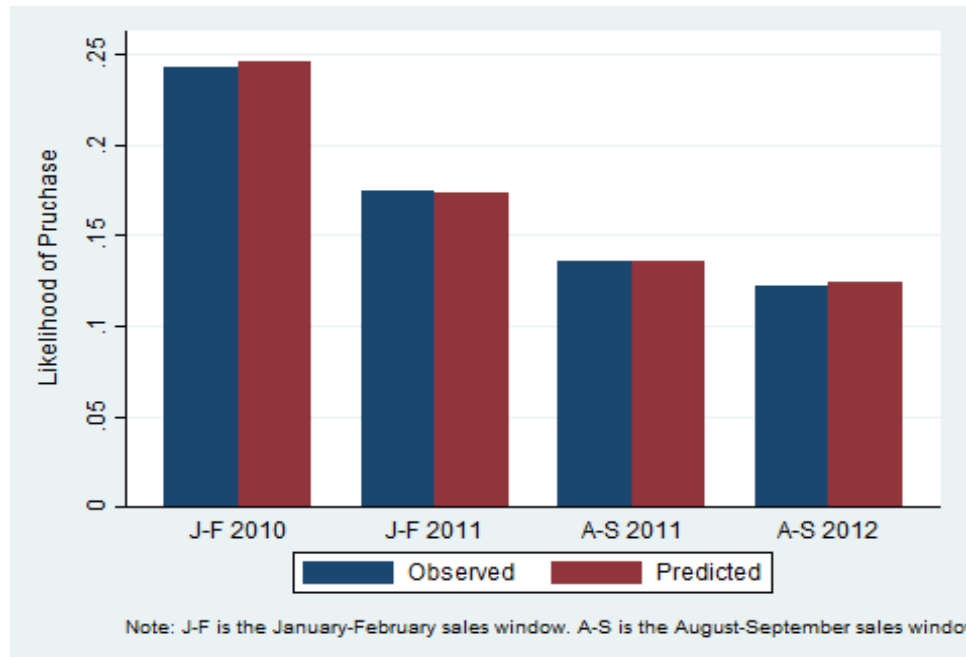
AVERAGE MARGINAL EFFECTS ON DEMAND FOR IBLI

VARIABLES	<u>ILBI Uptake (Probit)</u>		<u>Coverage (Conditional on purchase)</u>	
	Coefficient	Std. Err.	Coefficient	Std. Err.
<i>Prospective Adverse Selection:</i>				
Expected conditions: Good [#]	-0.0311	(0.0243)	-0.2709 ***	(0.0946)
Expected conditions: Normal [#]	0.0007	(0.0225)	-0.2118 **	(0.0842)
Pre-CZNDVI	-0.0009	(0.0013)	-0.0100 *	(0.0056)
Division Livestock Mortality	0.0577 ***	(0.0198)	-0.1865 **	(0.0767)
Division Risk	-0.0589 ***	(0.0207)	0.2002 **	(0.0842)
Division Correlation	0.2964 *	(0.1671)	-0.9204	(0.7385)
<i>Product Related Characteristics :</i>				
Correlation	0.0090	(0.0272)	-0.1397	(0.1035)
Extension Game	0.0104	(0.0215)	0.0267	(0.0707)
Ln(price)	-0.0289	(0.0437)	-0.4275 ***	(0.1342)
Observed Design Error (ODE)	-0.0073 ***	(0.0025)	-0.0062	(0.0127)
Coupon Dummy	0.1715 ***	(0.0304)		

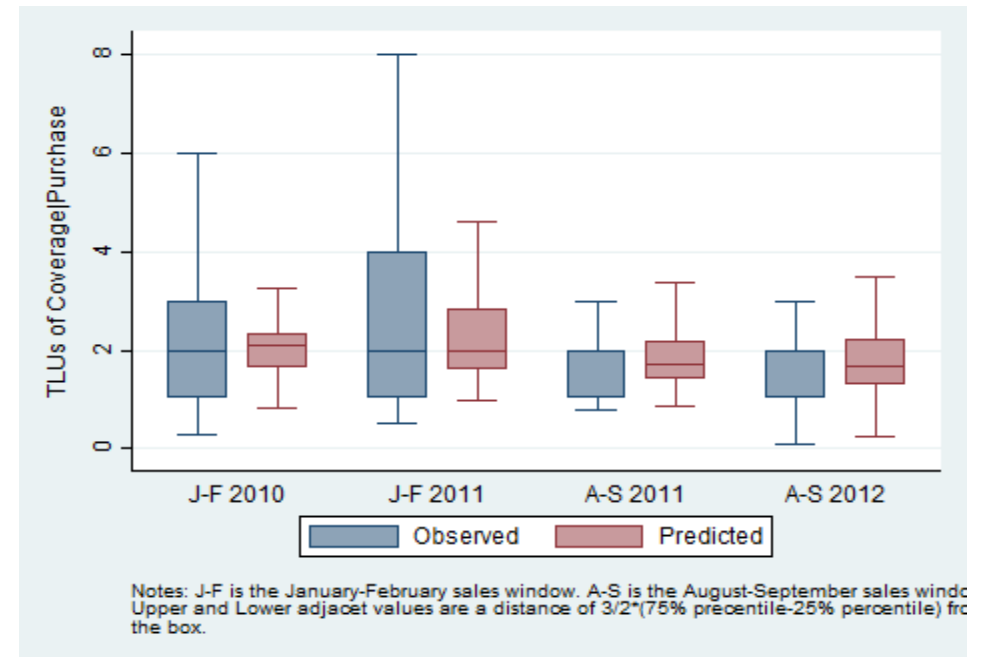
A complete list of covariates, coefficient estimates, and model statistics can be found at the end of this presentation. Robust and clustered standard errors in parentheses. [#]Omitted variable is *Expected conditions: poor*. Robust and clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

SUMMARY

Unconditional observed and predicted (Conditional FE) likelihood of purchasing IBLI



Observed and predicted (Conditional FE) level of purchases, conditional on being a purchaser



- Much of the variation in demand for index insurance remains unexplained ($R^2=0.135/0.258$)
- Household characteristics are important (Shapley's GOF decomposition= $0.27/0.45$)
- But so are basis risk and adverse selection (Shapley's GOF decomposition= $0.34/0.53$)

- Thank you
- Contact: ndj6@cornell.edu

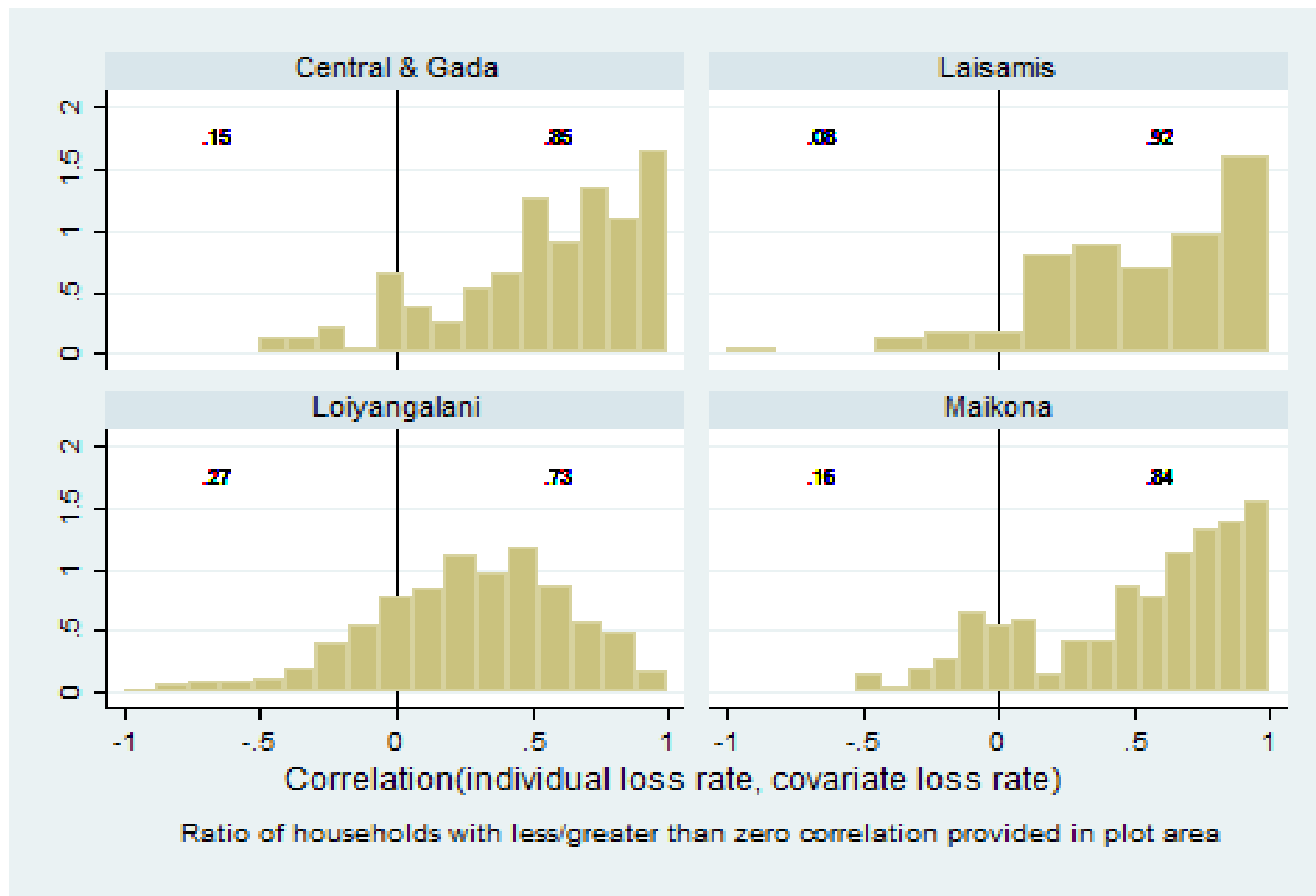


Summary Statistics

Variable	Never Purchase (N=450)		Did Purchase (N=382)		Difference	t-stat
	Mean	Std. Err.	Mean	Std. Err.		
Male	0.57	0.03	0.63	0.04	0.06	1.09
Age	47.10	1.05	48.67	1.80	1.57	0.76
Education	3.75	0.25	4.01	0.37	0.26	0.59
Risk Aversion:						
Neutral	0.26	0.03	0.25	0.04	-0.01	-0.14
Moderate	0.41	0.04	0.53	0.05	0.12	2.05 **
Extreme	0.33	0.03	0.22	0.04	-0.11	-2.28 **
Dependency Ratio	0.63	0.01	0.58	0.02	-0.04	-2.08 **
Social Groups	0.51	0.04	0.66	0.05	0.15	2.42 **
Asset Index	-0.14	0.05	-0.11	0.06	0.03	0.32
Income	7,190	465	6,997	454	-193	-0.30
Ratio Livestock Income	0.63	0.02	0.63	0.03	0.00	0.11
Herd Size	15.01	1.02	13.06	1.00	-1.94	-1.35
Livestock Mortality Rate	0.15	0.01	0.13	0.01	-0.02	-2.80 ***
Savings	0.08	0.01	0.08	0.01	0.00	-0.16
HSNP	0.27	0.02	0.26	0.03	-0.01	-0.27
HSNP Community	0.74	0.03	0.65	0.04	-0.08	-1.80 *
Expected Rangeland						
Conditions:						
Good	0.45	0.01	0.45	0.02	0.00	0.08
Normal	0.34	0.01	0.31	0.02	-0.03	-1.34
Poor	0.21	0.02	0.24	0.02	0.03	0.97
Pre-Czndvi	-2.77	0.09	-2.99	0.12	-0.22	-1.43
IBLI Coverage	0.00	0.00	0.13	0.00	0.13	35.24 ***
Risk (X 100)	5.84	0.52	4.05	0.33	-1.79	-2.92 ***
Correlation(M, CL)	0.44	0.02	0.46	0.03	0.02	0.43
IBLI Game	0.24	0.03	0.24	0.03	0.00	-0.02
Ln(Effective Price)	6.22	0.01	6.14	0.01	-0.07	-4.09 ***
Observed Design Error (%)	2.29	0.07	2.51	0.07	0.21	2.12 **
Coupon	0.55	0.02	0.64	0.02	0.09	2.78 ***

This table only includes the 832 balanced panel households in order to correctly categorize the “Never Purchase” households and maintain consistency in the periods and shocks captured in the summary statistics. *** p<0.01, ** p<0.05, * p<0.1

Histograms of the correlation between individual and covariate livestock mortality rates



Average marginal effects (AME) on IBLI uptake, from probit

VARIABLES	Pooled		Conditional FE	
	Coefficient	Std. Err.	Coefficient	Std. Err.
Household Period-Specific Characteristics:				
Male	0.0327	(0.0220)	0.0302	(0.0218)
Dependency Ratio	-0.0922*	(0.0536)	0.0121	(0.0888)
Social Groups [‡]	0.0270**	(0.0105)	-0.0004	(0.0118)
Asset Index [‡]	-0.0683***	(0.0261)	-0.0729**	(0.0290)
Ln(Income) [‡]	0.0039	(0.0077)	-0.0005	(0.0060)
Ratio income livestock [‡]	-0.0667*	(0.0341)	-0.0335	(0.0331)
TLU [‡]	0.0002	(0.0010)	0.0019**	(0.0010)
Livestock Mortality Rate [‡]	0.0033	(0.0378)	0.0289	(0.0386)
Savings (10TLU) [‡]	-0.0358	(0.0345)	-0.0481	(0.0402)
HSNP [‡]	0.0525**	(0.0231)	0.0558**	(0.0224)
Household Average Characteristics:				
Dependency Ratio			-0.1434**	(0.0583)
Social Groups			0.0570***	(0.0176)
Asset Index			-0.0089	(0.0204)
Ln(Income)			0.0041	(0.0089)
Ratio Income Livestock			-0.0207	(0.0454)
TLU			-0.0010	(0.0007)
Livestock Mortality Rate			-0.1084	(0.2105)
Savings (10TLU)			-0.0840	(0.0690)
Expected Rangelands: Good [#]			-0.0599	(0.0666)
Expected Rangelands: Normal [#]			-0.0746	(0.0657)
Prospective Adverse Selection:				
Expected conditions: Good [#]	-0.0514**	(0.0231)	-0.0311	(0.0243)
Expected conditions: Normal [#]	-0.0219	(0.0218)	0.0007	(0.0225)
Pre-CZNDVI	-0.0010	(0.0014)	-0.0009	(0.0013)
Division Livestock Mortality	0.0570***	(0.0203)	0.0577***	(0.0198)
Division Risk	-0.0522**	(0.0210)	-0.0589***	(0.0207)
Division Correlation	0.2814*	(0.1636)	0.2964*	(0.1671)
Product Related Characteristics :				
Existing IBLI Coverage	0.0239	(0.0482)	0.0172	(0.0497)
Risk	-0.6914***	(0.2416)	-0.3257	(0.3505)
Correlation	0.0064	(0.0267)	0.0090	(0.0272)
Extension Game	0.0043	(0.0220)	0.0104	(0.0215)
Ln(price)	-0.0234	(0.0473)	-0.0289	(0.0437)
Observed Design Error (ODE)	-0.0080***	(0.0025)	-0.0073***	(0.0025)
Coupon Dummy	0.1779***	(0.0341)	0.1715***	(0.0304)
Observations	3,292		3,292	
F-statistic	4.11		5.10	
P-value (model)	0.00		0.00	

Additional covariates not listed above include age, age², average age (for the Conditional FE model), education, level of risk aversion, HSNP Village and a constant. [‡]Variable is lagged one period. [#]Omitted variable is *Expected conditions: poor*. Robust and clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

Average marginal effects (AME) on level of purchase, conditional on purchase

VARIABLES	Pooled		Conditional FE	
	Coefficient	Std. Err.	Coefficient	Std. Err.
Household Period-Specific Characteristics:				
Male	0.0597	(0.0829)	0.0883	(0.0829)
Dependency Ratio	-0.3643	(0.2270)	-0.0773	(0.6169)
Social Groups [‡]	0.0400	(0.0464)	-0.0082	(0.0487)
Asset Index [‡]	0.1514	(0.1021)	0.2329**	(0.1019)
Ln(Income) [‡]	0.0230	(0.0319)	0.0419*	(0.0240)
Ratio Income Livestock [‡]	-0.3690***	(0.1289)	-0.4424***	(0.1605)
TLU [‡]	0.0050	(0.0040)	0.0106**	(0.0054)
Livestock Mortality Rate [‡]	0.0061	(0.1817)	-0.0091	(0.1696)
Savings (10TLU) [‡]	0.1428	(0.1466)	0.2676	(0.1982)
HSNP [‡]	-0.0684	(0.0932)	-0.1545	(0.1076)
Household Average Characteristics:				
Dependency Ratio			-0.4075*	(0.2449)
Social Groups			0.0998	(0.0681)
Asset Index			0.1970**	(0.0813)
Ln(Income)			0.0189	(0.0330)
Ratio Income Livestock			-0.0111	(0.1900)
TLU			0.0004	(0.0049)
Livestock Mortality Rate			0.0523	(0.7496)
Savings (10TLU)			0.0861	(0.2566)
Expected Rangelands: Good [#]			-0.6382***	(0.2469)
Expected Rangelands: Normal [#]			-0.5968**	(0.2455)
Prospective Adverse Selection:				
Expected Conditions: Good [#]	-0.3915***	(0.0869)	-0.2709***	(0.0946)
Expected Conditions: Normal [#]	-0.3270***	(0.0933)	-0.2118**	(0.0842)
Pre-CZNDVI	-0.0037	(0.0047)	-0.0100*	(0.0056)
Division Livestock Mortality	-0.1804**	(0.0829)	-0.1865**	(0.0767)
Division Risk	0.1682*	(0.0886)	0.2002**	(0.0842)
Division Correlation	-0.7921	(0.8214)	-0.9204	(0.7385)
Product Related Characteristics :				
Existing IBLI Coverage	-0.1203	(0.0979)	-0.2114**	(0.1037)
Risk	-1.1626	(1.0886)	-0.0205	(1.3111)
Correlation	-0.1599*	(0.0935)	-0.1397	(0.1035)
Extension Game	0.0156	(0.0686)	0.0267	(0.0707)
Ln(Price)	-0.4790***	(0.1214)	-0.4275***	(0.1342)
Observed Design Error (ODE)	-0.0070	(0.0124)	-0.0062	(0.0127)
Observations	3,292		3,292	
F-statistic	4.11		5.10	
P-value (model)	0.00		0.00	

Additional covariates not listed above include age, age², average age (for the Conditional FE model), education, level of risk aversion, HSNP Village, the Inverse Mills ratio, and a constant. [‡]Variable is lagged one period. [#]Omitted variable is *Expected conditions: poor*. Robust and clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1

AME OF INTERACTION TERMS

AME of the Observed Design Error on Demand for IBLI Across Premium Rates

	AME of Correlation(M,CL)	Std. Err.	t	P>t	Confidence Interval	
Uptake (probit):						
Extension Game						
No	0.003	0.031	0.10	0.917	-0.057	0.063
Yes	0.029	0.053	0.56	0.576	-0.074	0.133
Level (Conditional on Purchase):						
Extension Game						
No	-0.256	0.134	-1.91	0.056	-0.519	0.007
Yes	0.215	0.153	1.40	0.161	-0.086	0.516

AME of idiosyncratic risk on demand for IBLI across participation in the IBLI extension game

	AME of Observed Design Error	Std. Err.	t	P>t	Confidence Interval	
Uptake (probit):						
Price =						
Mean-1 SD	-0.003	0.003	-1.150	0.252	-0.009	0.002
Mean Price	-0.009	0.003	-3.540	0.000	-0.014	-0.004
Mean +1SD	-0.014	0.004	-3.770	0.000	-0.022	-0.007
Level (Conditional on Purchase):						
Price =						
Mean-1 SD	-0.003	0.014	-0.19	0.853	-0.030	0.025
Mean Price	-0.005	0.013	-0.36	0.718	-0.030	0.021
Mean +1SD	-0.007	0.016	-0.41	0.679	-0.039	0.025

SHAPLEY DECOMPOSITION OF PSEUDO R2 (%)

	IBLI Uptake (Probit)	Level of Purchase (Conditional on Purchase)
<i>Household Period-Specific Characteristics:</i>		
Demographics ^A	12.40	14.08
Financial ^B	14.42	30.85
<i>Prospective Adverse Selection:</i>		
Intertemporal ^C	2.46	18.39
Spatial ^D	5.12	13.84
<i>Product Related Characteristics:</i>		
Idiosyncratic Risk & Knowledge ^E	5.46	5.42
Design Risk & Price ^F	21.13	15.68
Coupon Dummy	35.32	
(Pseudo R ²) [R ²]	(0.135)	[0.258]

A group containing existing IBLI coverage and an indicator that the household is in an HSNP targeted community was also included in the regressions and decomposition; its Shapley contribution was 3.82% for uptake and 2.45% for level of purchase, conditional on purchasing.

^A Includes: gender, age, age², education, dependency ratio, social groups, level of risk aversion

^B Includes: asset index, asset index², ln(income), ln(income)², ratio income from livestock, livestock mortality rate, TLU, TLU², Savings(10TLU), HSNP

^C Includes: expected conditions dummies, Pre-Czndvi

^D Includes: division livestock mortality rate, division risk, division correlation

^E Includes: risk, correlations, game, correlation X game

^F Includes: Ln(price), observed design error, Ln(price) X observed design error