Productive Spillovers of the Take-up of Index-Based Livestock Insurance[¥]

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Abstract
Does the provision of livestock insurance raise the unintended consequence of stimulating excessive herd accumulation and less environmentally-sustainable herd movement patterns? The impact of insurance is theoretically ambiguous: if precautionary savings motives for holding livestock assets dominate, then we would expect to see households that receive index insurance reduce herd sizes and move less intensively. However if risk-adjusted investment motives dominate then we would expect them to build herds and move more. "Behavioural" or norm-based responses are also possible. To test between these theoretical possibilities we use the randomized provision of livestock insurance paired with novel, high frequency data collection. The results suggest that in the presence of insurance pastoralists accumulate larger herds, and move more intensively. This has implications for the potential ecological impacts scaling up of index insurance programs on the pastoralist rangelands, and for microinsurance and pastoralism more broadly.

Preliminary version; please do not cite

Prepared for the 2014 AAEA Annual Meeting

Keywords: East Africa, index-based livestock insurance, mobility, pastoralism

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[¥]We are grateful to colleagues including Stephen DeGloria, Kyle Gochnour, Monenobu Ikegami, Nathan Jensen, Madelaine Laba, and various colleagues at the International Livestock Research Institute for support in managing data collection and sharing other sources of data. We gratefully acknowledge funding support from NSF Expeditions in Computing Grant on Computational Sustainability #0832782, David R. Atkinson Center for a Sustainable Future grant #2011-RRF-sdd4, USAID BASIS AMA CRSP i4 grant "Index-based Livestock Insurance: Adaptation and Innovations for Ethiopia," and AusAID through the AusAID Development Research Awards Scheme under an award titled "The human and environmental impacts of migratory pastoralism in arid and semi-arid East Africa". The opinions expressed do not necessarily reflect the views of the U.S. Agency for International Development. The views expressed in the publication are those of the author(s) and not necessarily those of the Commonwealth of Australia. The Commonwealth of Australia accepts no responsibility for any loss, damage or injury resulting from reliance on any of the information or views contained in this publication. Barrett, Clark and Toth thank the International Livestock Research Institute for generous hospitality. We take responsibility for any errors.

Microinsurance has the potential to the transform the lives of the poor in low-income settings by providing a market-based approach to alleviate the effects of catastrophic shocks. In agricultural economies focused on livestock rearing, such as on the pastoralist[1] rangelands of arid and semi-arid East Africa, index-based livestock insurance products can reduce the burden of catastrophic shocks such as droughts (Chantarat, Barrett, Mude, & Turvey, 2007). But what are the behavioural spillovers of the introduction of such products on individual pastoralists, and what implications does this have if such products reach market scale in such settings? In particular, is there potential for livestock insurance to induce unsustainable behaviours such as the over-accumulation of livestock and grazing patterns that increase degradation? Such questions are critical to understand as various organizations seek to enhance demand for microinsurance, improve the cost parameters and supply networks of microinsurance, and consider optimal subsidization for the poor.

This study provides some initial evidence on these questions by estimating the behavioural spillovers of the take-up of index-based livestock insurance (IBLI) through a randomized field experiment in regions of southern Ethiopia where livestock raising is the primary livelihood. It focuses on evaluating the impact of IBLI on two key outcomes. First, we consider impacts on the accumulation of livestock assets. In theory it is possible that insurance induces destocking, as pastoralist households who had been motivated by precautionary savings substitute own-insurance for index insurance. On the other hand, if the presence of insurance actually increases the attractiveness of livestock by lowering the risk in an economy with few investment alternatives, or other norms toward livestock accumulation dominate, then we might expect to see livestock accumulation increase. We test this impact through the use of herd size data collected through a bi-annual survey of pastoralists. Initial

[1] Pastoralism is the branch of agriculture concerned with livestock raising.

findings point to the latter hypotheses: “treatment” households accumulate significantly greater livestock assets in the presence of insurance.

Second, we consider the impact of livestock insurance on herd accumulation patterns. Potential responses on this dimension could be driven by the perception of risk in the presence of insurance, along with modified valuations of the livestock asset in the presence of insurance. If insurance tends to alleviate worries about risk, then we might expect to see reduced mobility. We test for impacts on this dimension novel data collection using satellite-based GPS tracking collars on a sub-sample of livestock, which provides objective, high-resolution information on herding and grazing patterns. Initial findings again point to a potentially harmful ecological side effect of insurance take-up: if anything we see a reduction in movement distances and more concentrated movement, which might suggest the potential for greater damage to vegetation from trampling and increased local consumption.

This study provides at least two key contributions to the literature. First, it adds to a recently-emerging literature on the behavioural spillovers of microinsurance, and to our knowledge is the first paper to examine the spillovers of livestock insurance on productive behaviour. (Cole, Gine, & Vickery, 2013) investigate the impacts of rainfall insurance on productive behaviour among small- and medium-scale Indian farmers, also through a randomized experiment. Consistent with theoretical predictions, they find that increased insurance induces farmers to substitute existing activities for higher-risk, higher-return cash crops, though there does not seem to be a flow-through effect on expenditure.

Even more directly relevant is the study by Janzen and Carter (2013), who investigate the impacts of index-based livestock insurance in a similar setting (arid and semi-arid northern Kenya), focusing on how households trade off the choice between reducing consumption and protecting assets in the presence of a natural disaster. They are again aided by the randomized provision of insurance, crossed with a significant drought in the region that fell during the insurance pilot. Overall they find a large average treatment effect, and that it comes with interesting heterogeneity: households with large asset bases (those most likely to sell off assets during a drought) are 64% less likely to do so when insured, while those with small asset bases (those most likely to have to cut consumption to cope with the drought) are 43% less likely to do so. The former result is particularly relevant for the study at hand, as it hints at the presence of insurance inducing reducing of asset decumulation.

Second, this study provides some of the first insights into a critical issue for livestock insurance: whether unintended behavioural spillovers of livestock insurance (e.g., excess livestock accumulation and intensification of livestock grazing patterns) will lead to adverse impacts on environmental sustainability in the rangelands. These issues are especially pertinent in our area of study, the arid and semi-arid lands of the Horn of Africa, home to millions of people and large portions of the land in countries such as Kenya and Ethiopia. These regions offer potential to develop into economically-viable sources of livestock products, making use of otherwise largely unproductive land, but at the same time face new challenges due to climate change and economic pressures.

In the past decade interest has quickly increased in microinsurance as a tool to help the poor manage catastrophic risks in low-income settings. There has been particular interest around index insurance, as an innovative tool that enhances access to insurance for the poor by lowering the costs of administering insurance and verifying experienced loss (Chantarat, Mude, Barrett, & Carter, Forthcoming). Keen interest on this topic has been focused on demand for microinsurance and widespread, low-cost provision of microinsurance on the supply-side (Dercon, Kirchberger, Gunning, & Platteau, 2008). More recently work has been to emerge that evaluates the impacts of microinsurance on various welfare and productive outcomes ((Cole, Gine, Tobacman, Townsend, Topalova, & Vickery, Forthcoming), (Karlan, Osei, Osei-Akoto, & Udry, 2014)). This study begins to point toward consideration of broader spillovers and general equilibrium impacts of insurance.

The rest of this paper is organized as follows. First we provide a theoretical overview of this issue, illustrating the various possible responses to index insurance. We then proceed to discuss the study context and research design. This is followed be a presentation of the empirical methodology and the main results.

Behavioural Hypotheses

In this section we outline possible theoretical predictions of the impact of index insurance on:

1. Livestock movement and grazing patterns, and
2. Herd accumulation decisions (i.e., herd size)

The possible predictions, which will be outlined throughout the rest of the section, can be summarized in the following 2x2 matrix, where '+' means an increase and '–' means a decrease:[2]

Table 1. Summary of the implications of alternate models of pastoralist behaviour

		Herd accumulation	
		+	–
Herd movement	+	• If movement a + function of herd size / risk-adjusted investment	• If movement a – function of herd size / precautionary savings
	–	• If movement a – function of herd size / risk-adjusted investment • Wealth effect under income target • The 'misinformed moral hazard' hypothesis: households perceive the risks to herd accumulation as lower and the need to move (as prudent-but-costly risk management) less.	• If movement a + function of herd size / precautionary savings • Wealth effect under income target • Misunderstanding insurance, "payout a function of loss"

In the following two sub-sections we discuss the predictions of a few key models that might be salient in this context. Potential effects boil down to two key ways that pastoralists might

[2] While it is clear what + and – mean for herd accumulation, it is less clear what they mean for movement, as there are many ways to characterize movement. In general, for movement we take + to mean "more movement" – i.e., longer travel distances at higher speeds, which could be associated with greater search for resources over a broader area, which might indicate less potential for environmental degradation.

perceive herd assets and hence adjust to insurance on the herd accumulation margin. On the one hand, if pastoralists primarily see the herd as an outlet for precautionary savings, then we might expect insurance to lead to a reduction in herd size, because insurance reduces the need to continue to stockpile livestock under the risk of catastrophic loss. On the other hand, if herders primarily perceive the herd as an investment instrument, particularly in an economy with few investment alternatives, then insurance reduces the riskiness of livestock assets, making them a more attractive investment instrument.

How insurance trickles through to movement behaviour can work through two channels: an indirect channel through the effects of herd size on movement (i.e., if insurance leads to a change in herd size as discussed above, it may lead to different movement patterns since movement may vary as a function of herd size), and a direct effect as insurance changes the risk and return structure of the household's portfolio. Beyond these "rational responses" we can also consider responses due to misunderstandings of index insurance.

Herd Accumulation

A "standard" economic model of dynamic choice, positing utility maximizing pastoralists with strictly increasing utility defined over an objective such as consumption or income, allows for the possibility that herd accumulation behaviour could change in light of index insurance. There are at least two distinct mechanisms, which have opposing predicted effects on herd accumulation:

- Precautionary savings motive (–). If households use animals as precautionary savings for self-insurance purposes, then index insurance may provide a substitute means of self-insurance and thereby induce destocking. Hence pastoralists may follow the objective of maximizing herd size as opposed to maximizing consumption (in other words, wealth is the argument of the utility function they seek to maximize, rather than consumption). It could be that such behaviour would emerge as a social norm in response to highly variable environmental conditions that frequently devastate herd stocks. If the pastoralists perceive the existence of insurance to have changed their environment then their adaptive rule might change, with an attendant (relative) decrease in herd stocking.

- Risk-adjusted investment motives (+). If index insurance reduces loss risk and reduces risk of herd assets overall, thereby increasing the expected returns on investments in holding livestock, it could induce intertemporal reallocation in the form of reduced current consumption and increased total investment, leading to herd accumulation. Furthermore, at the beginning of any period, we can think of the pastoralist as facing a portfolio allocation problem, between herd assets and any other investment. If holding index insurance reduces herd loss risk, it then increases the expected value of herd asset investments and might induce herd accumulation through reallocation from other assets, if households held non-livestock assets. Finally, if the expected reduction in asset volatility due to index insurance leads to a "wealth effect in expectation" then households might be induced to invest more in the suddenly more-attractive livestock asset.

Movement

Conditional on herd size, a "standard" economic model of choice, positing utility maximizing pastoralists with strictly increasing utility defined over an appropriate objective such as consumption or income, and assuming pastoralists fully understand the incentives induced by index insurance, would predict no change in movement behaviour in light of index insurance. This is because index insurance only pays off as a function of events (changes in a satellite-based measure of conditions on the ground) that the pastoralist has no control over, so the presence of index insurance provides no incentives to change behaviour on this dimension. This is one of the classic justifications for index insurance.

One direct prospective effect is that the cost of purchasing insurance in the presence of binding liquidity constraints that forced reallocation of pastoralists' time toward cash-earning activities might potentially limit spatial movement. But since the insurance treatment under study had no cost to insured households, no such effect should exist in the present context.

Another related effect is the wealth effect that comes about because insurance reduces the (expected) volatility in income. This "wealth effect in expectation" might act like a traditional wealth effect, which could reduce effort in a target income model.

Given that herd movement choices could depend on herd size (e.g., if there is a minimal herd size necessary to engage in long distance, transhumant migration,[3] if larger herds might be more likely to stay at certain waterpoints or confer greater social prestige, thereby giving access to the best locations, etc.), in a dynamic setup we could expect index insurance to affect movement indirectly, through herd size effects. If, in general, we expect herd mobility to be positively associated with herd size, especially close to a poverty trap threshold, then we might expect tendency toward movement to be correlated with herd size. On the other hand, there is evidence from earlier research (Toth, Forthcoming) that relatively large herds tend to show less movement, perhaps due to prestige associated with larger herd sizes giving their owners a relative access advantage for certain resources.

To sum up the canonical model of rational herder behaviour, if precautionary savings motives dominate, then we would expect to see households that receive index insurance reduce herd sizes and potentially move less, while if risk-adjusted investment motives dominate, then we would expect them to build herds and move more.

Finally, we may consider the possibility that pastoralists may misunderstand how the insurance works. If they believe that payment is based on true loss, rather than on an index

[3] See (Toth, Forthcoming).

over which they have no influence (the actual case), then they may take on more costly/risky movement behaviours (e.g., not bothering to take animals to water/forage as frequently, taking them to waterpoints with higher probability of loss due to conflict or disease (but lower direct cost to them), etc.). Or if they know the index is calculated from a certain geographic area, they may endeavour to stay within that region so their experience is more likely to be correlated with the index.

Possibilities for No Response

In addition to the possibilities for positive or negative response summarized in Table 1, we might expect to see no change on *either* margin. One way to rationalize such an outcome is by hypothesizing that herder behaviour isn't guided by static or dynamic optimization incentives. This could be because choices are tradition-bound and invariant to incentive changes induced by introducing index insurance ("social norms"),[4] or due to misunderstandings of the incentives that insurance induces in ways that lead to no behavioural response. As a guide to the empirical work, we can think of this option as the traditional null hypothesis of "no change," which is tested against up to four alternatives corresponding to four distinct predictions in the table.

The Setting, the Intervention and Data Collection

In this section we provide background information on the study. We begin by discussing the setting on the arid and semi-arid lands of southern Ethiopia. We then discuss the sampling strategy for the study, the randomized provision of index-based livestock insurance, and the innovative use of satellite-linked GPS collars to collect high-resolution data on livestock

[4] Note that adherence to traditions or social norms does not necessarily imply an overall lack of dynamism in behaviour. For example, suppose that the norm is "maximize herd size," which evolved as an optimal response to the environmental uncertainty that pastoralists face. In this case the default behaviour would be to continue to accumulate livestock at a significant rate. A "treatment" response to insurance in this case might be a lower rate of accumulation or lack of further accumulation.

locations. Finally we present summary statistics on key baseline variables and show that these variables are largely balanced between treatment and control.

Study Context

The Borena Plateau along the southern border of Ethiopia with Kenya is home to many of Ethiopia's 8 million pastoralists and their livestock. The Borena Zone falls in the arid and semi-arid lands that span the border between the two countries. The system naturally has a bimodal rainfall distribution, with two rainy and two dry seasons during the year. During the dry season resources in the vicinity of the villages are generally not sufficient to support all of the herds' consumption needs, and so transhumant pastoralists temporarily migrate to water and forage points that are further afield. From time to time the system experiences more severe shocks due to drought (every 3-5 years in recent decades), which greatly increases the risk of herd loss due to undernourishment and disease.

In order to provide a market-based solution to these risk factors, researchers at a number of partner institutions collaborated to develop an index-based livestock insurance (IBLI) product. The IBLI product is designed to insure pastoralists against livestock morality that often accompanies the catastrophic droughts. IBLI contracts are based on the set of livestock insured. However payouts are not based on realized loss. Rather, the product uses freely-available satellite data on rangeland vegetation conditions in order to provide a trigger for insurance payouts. IBLI was officially launched in southern Ethiopia in July, 2012.[5]

Sample Selection and Livestock Collaring, and Intervention

In August, 2011, 20 households in 5 villages on the Borena plateau in southern Ethiopia were selected for a study on the impacts of index-based livestock insurance (IBLI). The sample was stratified to cover households from four segments[6] of the livestock herd size distribution in each community (leaving out the poorest, immobile households, and the very wealthiest

[5] See http://livestockinsurance.wordpress.com/ibli-southern-ethiopia/.
[6] We sample from the 35-50%, 50-65%, 65-80%, and 80-95% quantiles of the herd size distribution.

households). Three cows from each household's livestock herd were fitted with GPS tracking collars, collecting precise locational information at 5-minute intervals on an ongoing basis (data collection is continuing through June, 2014). When faced with challenges such as failure of collar devices in the field or the need to remove a collar from a cow (due to death, sale, etc.), the goal was always to maintain consistency in data collection through re-allocating collars.

In August, 2012, half the households (10) were randomly selected to receive free IBLI policies covering 15 of their cattle. The "treatment" households have continued to receive free policies through 2014.

<u>Data</u>

In conjunction with the GPS collar installation and maintenance, a baseline household survey was also fielded on each of the 20 study households, which has been followed up biannually through February, 2014. The study primarily focuses on herding activity: herd stock, movement, and reasons for movement. In addition, the 20 households are a subset of a 500+ household panel survey that provides further detailed information about household demographics and socio-economic characteristics and behaviours. This survey has been collected annually since March, 2012. Of particular interest for this study is a module that captures households' knowledge of IBLI. This includes 8 questions designed to measure households' understanding of how IBLI works, which we use to construct an index of heterogeneity of knowledge of IBLI. This is important because since this study involves giving away IBLI contracts for free, it could be that behavioural responses are not very informative because they do not reflect the behaviours of an IBLI purchaser (the relevant behaviour if we want to draw policy guidance on what might happen if IBLI were taken to scale). In conjunction with the household surveys, we have also built up a database of waterpoint locations in the Borena plateau, using various approaches from remote sensing to participatory mapping. This gives us an indication of resource locations.

Based on the availability of data from the household surveys and GPS collars, this study focuses on the period August, 2011 to August, 2013. Hence we have 1 year of pre-treatment data and 1 year of post-treatment data.

These original data are complemented by further sources of remote sensing data and geographic information. In particular, we measure groundcover conditions with freely-available data on normalized difference vegetation index (NDVI), at 250m x 250m spatial resolution and 16-day time intervals.

Description of Data and Balance Checks

We report on baseline conditions on a number of variables capturing household demographics and asset status in Table 2, and then conduct balance checks. These statistics are based on averaging responses across the two pre-treatment household surveys (August, 2011, and February, 2012). The typical household has about 8 total members, and is headed by a male of about 50 years. The only source of near imbalance is on sex of the HH head; there is one female headed household in the control group and none in the treatment group. The only variable that is (highly) statistically significant between treatment and control is the number of subherds, which measures the number of independently-traveling groups that a household divides its livestock into. The treatment group has about 20% more subherds on average than the control. This baseline difference will be accounted for in some of the regressions through household fixed effects. We will discuss other baseline variables in the next section, as we cover the outcome variables in the study.

Empirical Methods: Measurement and Regression Framework

In this section we provide a more detailed discussion of how we measure outcomes, and present the basic differences-in-differences regression framework that we use to evaluate the impact of index insurance on outcomes.

Once concern with inference for this study is that the data structure is somewhat non-standard – the number of sample units is small, while in some cases the number of sample periods is very large (e.g., for movement data, which is collected at 5-minute intervals, and provides many observations even when averaged over the course of a day). This data structure, sometimes called "small n, large t" is occasionally seen in the literature on field experiments (e.g., (Bloom, Eifert, McKenzie, Mahajan, & Roberts, 2013)). The procedure for correcting standard errors in this instance is still debated. Hence we follow the approach of estimating results based on standard estimators, and then comparing results using a flexible fit for standard errors (using the so-called jackknife procedure).

Measurement of Outcomes: Herd movement and grazing patterns

The GPS data on herd movements allow us to construct a number of indicators of livestock movement. These measures allow us to characterize livestock movement patterns, to draw inferences about potential changes in the sustainability of movement patterns.

In this study we focus on the following four measures, calculated on a daily basis and averaged within-household over the study period:

1. "Max. dist trav. from camp." We are able to locate the "camp site" of each livestock collar by the night time location of the collar. The camp is the relevant anchor point for assessing the collared animal's movements during the day. This measure captures the maximum observed distance between the camp and the collar in the course of the day. High distance travelled may indicate that movements are less intensive in any particular location, and hence less likely to cause degradation. At the same time, more movement may be indicative of greater metabolic energy expenditure.

2. “Average speed.” Given that we have high-resolution data on collar locations (5-minute intervals), we can calculate “speed” as the amount of distance moved per 5-minute period. This measure averages the speed readings through the course of a day. Low average speeds might indicate that livestock are spending more time in the day to consume (and trample) vegetation.
3. “Tortuosity.” Tortuosity measures how twisted a path (i.e., curve) is. A straight line will have the lowest possible tortuosity, while a circle has the highest possible tortuosity. This can again be taken as a measure of intensity of movement – livestock following straight paths are more likely to have relatively isolated impacts on vegetation cover.
4. “Min. dist water.” This variable measure the minimum distance of the cow from a known water point during the course of the day. A reading near zero would indicate that watering had occurred.

Measurement of Outcomes: Herd accumulation decisions

To capture whether the presence of insurance induces herd accumulation or decumulation, we measure herd stock on a bi-annual basis. In this study we focus on cattle, since that is the part of the household’s herd that is directly covered by insurance. Herd size is measured in Tropical Livestock Units (TLU), where one cow is given a value of one TLU.

Measurement of Outcomes: Subjective concerns

In addition to the primary results on herd movement and accumulation, we also report on the subjective concerns of livestock herders. In the survey respondents are asked to report on subjective concerns for each of their subherds, which for this study we have aggregated across the subherds. The concerns include issues such as lack of availability of vegetation or water, lack of funds available to be able to migrate and concerns about disease and raiding affecting livestock. A full listing of definitions is provided in the Appendix.

Regression Framework

Our basic objective is to determine whether pastoralists' movement and herd accumulation behaviours change in the presence of index insurance. With pre-treatment and post-treatment data in hand we use the following primary differences-in-differences specification:

$$y_{ijt} = \beta_1 Treat_i + \beta_2 Post_t + \beta_3 Treat_i * Post_t + \gamma X_{ijt} + FE_{ij} + \varepsilon_{ijt},$$

where *i* indexes households, *j* indexes villages and *t* indexes time periods. *Treat* and *Post* are dummy variables for treatment households and post-treatment periods, respectively. Our main coefficient of interest is β_3, which captures the impact of treatment in the post-treatment period. In addition we control for time-variant household and village-level characteristics such as age of household head, local NDVI, and the number of household members, through X_{ijt}, and either household-level or village-level fixed effects through FE_{ij}.

In addition to the standard differences-in-differences estimator, we also present results in which we take differences along a further dimension: understanding of index insurance. As noted, the large household survey provides a module collecting information on this issue through questions testing understanding of IBLI such as how frequently the payouts will be made, who makes the IBLI payments, and the expected payout. Hence we also consider the specification:

$$\begin{aligned} y_{ijt} = {} & \beta_1 Treat_i + \beta_2 Post_t + \beta_3 IBLI\ index_i + \beta_4 Treat_i * Post_t + \beta_5 Treat_i * IBLI\ index_i \\ & + \beta_6 Post_t * IBLI\ index_i + \beta_7 Treat_i * Post_t * IBLI\ index_i + \gamma X_{ijt} + FE_{ij} \\ & + \varepsilon_{ijt}, \end{aligned}$$

where *IBLI index* represents the index of IBLI knowledge based on responses to the IBLI understanding questions in the large household survey. Hence β_7 is the main coefficient of interest.

Results

The regressions are collected in Tables 3-9 in the Appendix. The provide evidence on the impacts of IBLI on (1) herd accumulation decisions, (2) herd movement and grazing patterns and (3) subjective concerns about herding activity.

Herd accumulation decisions

The impacts of insurance on herd accumulation decisions can be seen in Table 3. The first two columns give results using village dummies, while the subsequent columns use household fixed effects. Columns 1 and 3 present results using standard robust standard errors, while the remaining columns present results using the jackknife method. The last column presents the "triple interaction" allowing for heterogeneity in IBLI knowledge.

The main impact estimates are the coefficients on Treatment*Post on the first four columns. There we see that under village effects R-squared is lower and treatment impacts are not statistically significant (though they are positive and economically significant at about one quarter of mean herd size). Under household fixed effects we see even larger, positive impacts of insurance on herd accumulation, statistically significant at the 10% level (nearly significant at the 5% level). The treatment estimate is about 11 cattle per household, or about one-third the average herd size and more than one-quarter of a standard deviation. In the last column we see that variation in IBLI knowledge does not seem to explain variation in response on the herd size dimension.

Taken taker these results provide evidence consistent with the theory of risk-adjusted investment motives, in which insurance makes livestock holding more attractive (by reducing investment risk), particularly in a world with few alternative investments. These findings are also consistent with norm-based explanations for excess herd stocking, although such theories would need to account for how norms would respond to insurance. In any case they provide confirmation to concerns about the potential of IBLI to increase environmental degradation through increase herd stocking.

Herd movement and grazing patterns

The results on herd movement and grazing patterns are collected in Tables 4-7. Altogether the results seem to further confirm concerns about potential adverse environmental impacts from IBLI, due to a perceived reduction in risk on the part of households in the presence of insurance (reducing the need for movement). In Table 4 we see that where results are significant they confirm significantly less daily movement. Furthermore when we allow for treatment heterogeneity due to heterogeneous understanding of IBLI we find that the better households understand IBLI, the greater the negative response in terms of the distance moved from camp on a daily basis. In Table 5 we see largely consistent results for average speed – impacts in columns 1, 2, and 5 are statistically significant and negative. Interestingly under household fixed effects the results in columns 3 and 4 turn positive, however the coefficient estimates are much smaller. The results from Table 7 on the impact on minimum distance to water again follow this pattern – a reduction in distance to water is supported (perhaps indicating less movement, with more clustering around water) and where positive coefficients are observed they are an order of magnitude smaller. Results on tortuosity from Table 6 are not clear and hence not worth summarizing.

While the mechanisms behind these observations are still unclear, one story consistent with all the evidence thus far is that insurance induces households to increase their herd stocks, which draws them into greater herd maintenance activity (e.g., watering animals). The results are also consistent with the findings of (Toth, Forthcoming) that larger herds tend to move less frequently and move shorter distances when they do move.

Subjective concerns

The results on subjective concerns do not show a lot of action, with most impact estimates insignificant. The main concern that is near significant is the concern about not enough water for livestock, which is significant at the 10% level. This again consistent with heightened household concerns about water access in the presence of a larger herd.

Conclusion

In this study we consider the possibility that the introduction of index-based livestock insurance on the arid and semi-arid rangelands of East Africa could have the unintended consequence of inducing increased herd stocking and unsustainable livestock movement and grazing behaviours. Initial results point to the potential for adverse ecological consequences, with livestock movements shortening and intensifying, while herd stocks increase by an economically-significant amount in response to insurance. Of course these results come with the significant caveat that there are based on a small sample, and do not consider interactions or equilibrium processes that might regulate these forces if insurance were to roll out at scale. Hence while we should be very cautious about drawing policy conclusions from these results, they do point to a need for further research on unintended consequences of introducing innovative products such as index insurance.

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Appendix: Variables and Tables

Listing of Subjective Concerns Variables

1. Concerns for movement: not enough pasture
2. Concerns for movement: not enough water
3. Concerns for movement: animal disease
4. Concerns for movement: animal theft/raiding
5. Concerns for movement: insecurity/violence
6. Concerns for movement: not enough profit to cover migration
7. Similar
8. Concerns for movement: human sickness
9. Concerns for movement: not enough herding labor
10. Concerns for movement: slow animal growth

Table 2. Balance Check

Variable name	Treatment	Treatment SD	Control Mean	Control SD	Diff p-value	
Age HH head	49.55	9.55	49.95	16.72	0.93	
Sex HH head	1.00	0.00	1.10	0.31	0.15	
Num HH member	7.90	3.16	8.40	5.07	0.71	
Num subherds	3.65	1.04	2.75	1.02	0.01	***
TLU whole herd	32.15	41.21	26.40	19.63	0.58	
TLU cattle only	36.75	41.89	29.75	22.42	0.51	
IBLI know. Index (/8)	5.40	0.82	5.50	0.83	0.70	
Concern 1	1.57	0.87	1.50	1.05	0.81	
Concern 2	1.26	0.91	1.84	1.69	0.19	
Concern 3	0.83	0.68	0.76	0.61	0.72	
Concern 4	0.58	0.56	0.62	0.61	0.86	
Concern 5	0.68	0.67	0.71	0.92	0.91	
Concern 6	0.71	0.86	0.71	0.75	0.99	
Concern 7	0.75	0.87	0.78	0.84	0.91	
Concern 8	0.56	0.52	0.64	0.67	0.66	
Concern 9	0.93	0.87	0.89	0.89	0.88	
Concern 10	0.69	0.72	0.78	0.95	0.74	
N	20		20			

Note: *** p<0.01, ** p<0.05, * p<0.1

Note: TLU = Tropical Livestock Units (1 TLU = 1 cow = 0.7 camels = 0.1 sheep or goats)

Table 3. Impact of insurance on household's cattle TLU

	TLU just cattle	TLU just cattle	TLU just cattle	TLU just cattle	TLU just cattle
Treatment	-3.728	-3.728	-154.319**	-54.521	-64.221
	-7.311	-7.703	-68.823	-56.832	-66.392
Post	4.506	4.506	-22.114**	-22.114**	-57.955
	-18.931	-19.863	-9.595	-11.004	-79.872
Treament*Post	7.944	7.944	11.167*	11.167*	36.459
	-11.238	-11.767	-5.711	-6.527	-60.818
Age of HH Head	-0.114	-0.114	28.638***	28.638**	30.249**
	-0.63	-0.669	-10.536	-12.306	-13.788
Age of HH head squared	0	0	-0.117	-0.117	-0.133
	-0.006	-0.007	-0.079	-0.093	-0.11
HH members	2.447**	2.447**	-109.285***	-119.264***	-122.133***
	-1.057	-1.116	-31.342	-39.123	-41.562
Post*IBLI index					6.581
					-14.454
Treatment*Post*IBLI index					-4.631
					-10.874
HH FE	NO	NO	YES	YES	YES
Village FE	YES	YES	NO	NO	NO
R-squared	0.716	0.716	0.939	0.939	0.939
Adj. R-squared	0.685	0.685	0.919	0.919	0.917
N	100	100	100	100	100

* p<0.10, ** p<0.05, *** p<0.01

Table 4. Impact of insurance on max distance moved from camp

	Max. dist trav. from camp	Max. dist trav. from camp	Max. dist trav. from camp	Max. dist trav. from camp	Max. dist trav. from camp
Treatment	4.203***	1.809***	4.350***	-3.867	.
	-0.051	-0.061	-0.099	-3.919	.
Post	4.204***	2.008***	-0.064	-0.113	-1.159***
	-0.04	-0.053	-0.052	-0.146	-0.378
Treament*Post	-4.422***	-1.749***	0.101	0.097	5.103***
	-0.078	-0.087	-0.084	-0.084	-0.591
Age of HH Head				0.552***	0.217
				-0.169	-0.177
Age of HH head squared				-0.005***	-0.003**
				-0.001	-0.001
HH members				-0.651*	-0.163
				-0.353	-0.527
Number IBLI Q correct (/8)					0.588
					-2.21
Post*IBLI index					0.205***
					-0.065
Treatment*IBLI index					-0.252
					-0.896
Treatment*Post*IBLI index					-0.942***
					-0.109
HH FE	NO	NO	YES	YES	YES
Village FE	NO	YES	NO	NO	NO
R-squared	0.507	0.632	0.729	0.73	0.731
Adj. R-squared	0.507	0.632	0.729	0.729	0.731
N	17569	17569	17569	17569	17569

* p<0.10, ** p<0.05, *** p<0.01

Table 5. Impact of insurance on average speed of movement

	Average speed	Average speed	Average speed	Average speed	Average speed
Treatment	0.616***	0.265***	0.617***	0.691**	.
	-0.004	-0.006	-0.008	-0.343	.
Post	0.642***	0.317***	0.005	0.036***	-0.071**
	-0.003	-0.005	-0.004	-0.013	-0.032
Treament*Post	-0.637***	-0.261***	0.020***	0.019***	0.476***
	-0.007	-0.008	-0.007	-0.007	-0.048
Age of HH Head				0.016	-0.015
				-0.015	-0.015
Age of HH head squared				-0.000***	-0.000*
				0.00	0.00
HH members				0.038	-0.140***
				-0.031	-0.045
Number IBLI Q correct (/8)					0.645***
					-0.192
Post*IBLI index					0.021***
					-0.006
Treatment*IBLI index					0.202***
					-0.079
Treatment*Post*IBLI index					-0.086***
					-0.009
HH FE	NO	NO	YES	YES	YES
Village FE	NO	YES	NO	NO	NO
R-squared	0.66	0.791	0.893	0.893	0.894
Adj. R-squared	0.66	0.791	0.893	0.893	0.894
N	17569	17569	17569	17569	17569

* p<0.10, ** p<0.05, *** p<0.01

Table 6. Impact of insurance on tortuosity

	Tortuosity	Tortuosity	Tortuosity	Tortuosity	Tortuosity
Treatment	8283.504***	3775.117	17721.010*	-123887.949	.
	-2697.799	-2629.026	-9602.796	-102710.285	.
Post	485.393***	-3764.896***	-8831.804***	-8653.658***	-2466.809
	-139.155	-1285.18	-2368.313	-2756.245	-20493.715
Treament*Post	-8429.610***	-4160.584	37.353	-94.086	-45886.69
	-2702.061	-2732.128	-3611.596	-3587.582	-40856.238
Age of HH Head				12608.118	15608.221
				-8675.508	-10619.896
Age of HH head squared				-128.236	-150.723
				-84.612	-102.547
HH members				-15917.7	-9824.106
				-11683.835	-7108
Number IBLI Q correct (/8)					-31738.501
					-23161.537
Post*IBLI index					-1285.098
					-3925.43
Treatment*IBLI index					-37797.229
					-28025.158
Treatment*Post*IBLI index					8650.759
					-7341.309
HH FE	NO	NO	YES	YES	YES
Village FE	NO	YES	NO	NO	NO
R-squared	0.001	0.002	0.004	0.005	0.005
Adj. R-squared	0.001	0.002	0.003	0.004	0.004
N	17569	17569	17569	17569	17569

* p<0.10, ** p<0.05, *** p<0.01

Table 7. Impact of insurance on minimum distance to water

	Min. dist water	Min. dist water	Min. dist water	Min. dist water	Min. dist water
Treatment	4.136***	4.717***	4.198***	7.18	.
	-0.072	-0.093	-0.088	-4.486	.
Post	4.467***	4.730***	0.270***	0.608***	0.622*
	-0.062	-0.087	-0.063	-0.175	-0.319
Treament*Post	-3.713***	-4.423***	0.277***	0.265***	4.527***
	-0.123	-0.124	-0.101	-0.101	-0.622
Age of HH Head				0.151	-0.117
				-0.173	-0.173
Age of HH head squared				-0.004***	-0.003**
				-0.001	-0.001
HH members				0.264	-2.051***
				-0.394	-0.638
Number IBLI Q correct (/8)					8.072***
					-2.603
Post*IBLI index					0.016
					-0.055
Treatment*IBLI index					1.728*
					-0.998
Treatment*Post*IBLI index					-0.811***
					-0.123
HH FE	NO	NO	YES	YES	YES
Village FE	NO	YES	NO	NO	NO
R-squared	0.384	0.487	0.745	0.745	0.746
Adj. R-squared	0.384	0.486	0.745	0.745	0.746
N	17569	17569	17569	17569	17569

* p<0.10, ** p<0.05, *** p<0.01

Table 8. Impact of insurance on subjective concerns

	Con1: Not enough pasture	**Con2: Not enough water**	**Con3: Animal disease**	**Con4: Animal theft/raid**	**Con5: Insecurity/violence**
IBLI_gift==2	83.335***	74.996***	10.345	31.432*	44.688**
	-21.106	-24.309	-11.668	-17.406	-18.095
post==1	0.104	-0.561	0.297	0.276	0.08
	-0.466	-0.439	-0.299	-0.346	-0.405
IBLI_gift==2 & post==1	-0.403	-1.002*	0.44	-0.034	-0.05
	-0.436	-0.504	-0.273	-0.273	-0.342
Age of HH Head	1.982***	1.338*	0.391	0.874*	0.848
	-0.668	-0.742	-0.341	-0.473	-0.527
Age of HH head squared	-0.009	-0.001	-0.003	-0.005	-0.001
	-0.006	-0.006	-0.003	-0.003	-0.005
HH members	-8.410***	-7.281***	-1.068	-3.242*	-4.415**
	-2.178	-2.523	-1.207	-1.78	-1.863
HH FE	YES	YES	YES	YES	YES
R-squared	0.866	0.787	0.82	0.791	0.82
Adj. R-squared	0.823	0.72	0.763	0.725	0.763
N	100	100	100	100	100

* p<0.10, ** p<0.05, *** p<0.01

	Con6: Profit--not enough buyer	**Con7: Profit--not enough buyer lo**	**Con8: Not enough labor (sickness)**	**Con9: Shortage HH food**	**Con10: Finna (slow animal growth)**
IBLI_gift==2	31.046**	42.112***	21.835***	29.748***	44.063***
	-13.576	-12.474	-6.928	-10.361	-14.249
post==1	0.084	-0.149	-0.05	-0.33	-0.046
	-0.381	-0.313	-0.159	-0.287	-0.346
IBLI_gift==2 & post==1	-0.168	-0.272	-0.006	0.141	-0.202
	-0.289	-0.283	-0.195	-0.293	-0.296
Age of HH Head	0.768**	0.834**	0.361*	0.702**	0.850**
	-0.342	-0.377	-0.213	-0.307	-0.38
Age of HH head squared	-0.003	-0.002	0	-0.003	-0.001
	-0.003	-0.003	-0.002	-0.003	-0.003
HH members	-3.180**	-4.158***	-2.118***	-3.008***	-4.339***
	-1.351	-1.29	-0.716	-1.075	-1.455
HH FE	YES	YES	YES	YES	YES
R-squared	0.78	0.81	0.847	0.785	0.808
Adj. R-squared	0.711	0.75	0.798	0.717	0.747
N	100	100	100	100	100

* p<0.10, ** p<0.05, *** p<0.01