Pre-Analysis Plan
Long-term Effects of Index-Based Livestock Insurance

Chris Barrett* Nathan Jensen† Karlijn Morsink‡
Hyuk Harry Son§

March 2023

*Charles H. Dyson School of Applied Economics and Management and Jeb E. Brooks School of Public Policy, Cornell University, USA, Email: cbb2@cornell.edu

†Independent researcher, N.Jensen@cgiar.org

‡Utrecht University School of Economics, The Netherlands. Morsink is also affiliated with the Development Economics Group at Wageningen University, The Netherlands and the Center for the Economics Analysis of Risk at Georgia State University, USA. Email: k.morsink@uu.nl

§Utrecht University School of Ecnomics, The Netherlands and Charles H. Dyson School of Applied Economics and Management, Cornell University, USA. Email: hs924@cornell.edu

Contents

1 Trial Information

- Title: Long-term Effects of Index-Based Livestock Insurance
- Location: Kenya and Ethiopia
- Principal Investigators:
  - Chris Barrett (Cornell University)
  - Nathan Jensen (Indenpendent Researcher)
  - Tagel Gabrehiwot Gidey (Environment and Climate Research Centre, Policy Studies Institute)
- Keywords: Index insurance, long term effects
- Additional Keywords: Ethiopia, Kenya
- Funding:
  - US Agency for International Development (USAID) Agreement No. LAG-A-00-96-90016-00 through Broadening Access and Strengthening Input Market Systems Collaborative Research Support Program (BASIS AMA CRSP)
  - The Australian Department of Foreign Affairs and Trade through the Australia Development Research Awards Scheme under an award titled "The human and environmental impacts of migratory pastoralism in arid and semi-arid East Africa"
  - JSPS Grant-in-Aid for Scientific Research (B)-26301021

- The UK Department for International Development, the Australian Department of Foreign Affairs and Trade and the Agriculture and Rural Development Sector of the European Union through DfID accountable (Grant agreement No: 202619-101)
- The UK Department for International Development through FSD Trust Grant SWD/Weather/43/2009
- The United States Agency for International Development (USAID) (Grant No: EDH-A-00-06-0003-00)
- The World Bank's Trust Fund for Environmentally and Socially Sustainable Development (Grant No: 7156906)
- The CGIAR Research Programs on Climate Change, Agriculture and Food Security (CCAFS) and Dryland Systems.
- Standing Panel on Impact Assessment (SPIA) of the CGIAR and through the CGIAR Research Program on Livestock.
- Foreign, Commonwealth & Development Office (FCDO) Project "Extreme Poverty - Building Evidence for Effective Action", sponsored through Oxford Policy Management Limited (Award Number: POR008864)

- IRB Approval
  - Institutional Review Board (Cornell University):
    - Protocol ID No 0907000655
    - Protocol ID No 1203002881
    - Protocol ID No 2008009760, Approval date: August 10, 2021
  - International Livestock Research Institute Institutional Research Ethics Committee:

    - ∗ ILRI-IREC2015
    - ∗ ILRI-IREC2020-53, Approval date: February 5, 2021
  - NACOSTI: NACOSTI/P/20/7050

2 Summary

2.1 Research Questions

- To what extent the Index-Based Livestock Insurance have long-term welfare impact on pastoralists?

2.2 Outcomes of interest

2.2.1 First stage outcome

- Cumulative insurance uptake: The number of seasons when a pastoralist purchased ANY IBLI policy

2.2.2 Primary outcomes

- Herd size and composition
- Total household income
- Educational attainment: Maximum years of education within a household

2.2.3 Secondary outcomes

- Herd management expenditure (on veterinary expense)
- Milk income per cattle market value equivalent
- Livestock loss per cattle market value equivalent
- Distress sales of livestock in response to indemnity payments
- Children's activity choices: Share of children working full-time, part-time, and studying full-time
- IBLI uptake in the past 12 months

2.3 Research design

The original research designs to evaluate the impact of Index-Based Livestock Insurance offered discount coupons after randomly selecting the recipients and the discount rates that they will receive. We instrument the cumulative IBLI purchase experiences with these past coupon receipt experiences to estimate the long-term effects of IBLI.

3 Intervention

The intervention was implemented from 2010 to 2015 in Marsabit district of Kenya with Takaful Insurance, and from 2012 to 2015 in Borena zone of Ethiopia with Oromia Insurance Company as implementing partners. In the original research design, discount coupons for insurance premium were distributed randomly within each community (sublocation in Kenya, kebele in Ethiopia). Details of this intervention are specified in Jensen, Barrett, and Mude (2017) for Kenya and Matsuda, Takahashi, and Ikegami (2019) for Ethiopia, respectively.

In addition to the discount coupons, interventions to transfer knowledge about the IBLI product were offered in both countries. In Kenya, a selected subsample of communities played IBLI knowledge games designed to illustrate key features of IBLI products. In Ethiopia, learning kits – including skit tapes and cartoons – were provided to randomly chosen subset of the communities. We do not explore the effect of these interventions in our analysis since the immediate effect of these interventions on insurance uptake were shown to be minimal. (Jensen, Mude, and Barrett, 2018; Takahashi et al., 2016)

4 Experimental Design

- Treatment: Randomized discount rates for insurance premium
  - Kenya: Randomly chosen 60 percent of the sample households received coupons. 10 to 60 percent discount at interval of 10 percentage points.
  - Ethiopia: Randomly chosen 80 percent of the sample households received coupons. 10 to 80 percent discount at interval of 10 percentage points.
- Randomization method:
  - Randomization was conducted in office by a computer.
- Randomization unit: Individual households, stratified at community level.

- For the details of the original study design, refer to Jensen, Barrett, and Mude (2017) for Kenya and Matsuda, Takahashi, and Ikegami (2019) for Ethiopia, respectively.

5 Sampling Frame

Sampling frame of the original pilot is specified in codebooks, both of which are available online.[1]

5.1 Kenya

Sampling is clustered at the sub-location level. Of the 47 sublocations in Marsabit district at baseline in 2009, 16 sublocations were chosen to represent a variation of livestock systems, agro-ecologies, market accessibility, and ethnic composition. Household rosters were compiled by chiefs and local elders, and the random sample of one-third of the population (from each livestock tercile) was selected after stratified by livestock terciles.

5.2 Ethiopia

Sampling is clustered at the reera level. In eight southernmost woredas of Borena zone, 25 reeras maximizing the geographic distribution and capturing livelihood variation, as well as accessible by vehicles were chosen. Household rosters were compiled by local agents, and the random sample of 15 percent of the total population was

[1] `https://data.ilri.org/portal/dataset/ibli-marsabit-r1` for Kenya, and `https://data.ilri.org/portal/dataset/ibli-borena-r1` for Ethiopia.

selected after stratified by livestock terciles. The final sampling units were 17 after combining a few reeras together to ensure at least 25 households were chosen from one unit. After combining a few reeras, each group of reeras is unique to a kebele – a higher administrative unit than reera in Ethiopia. Therefore, we consider kebele as a sampling unit for Ethiopia.

6 Data Sources

6.1 IBLI Panel survey

The original research designs during pilot period included longitudinal household surveys collected annually from a sample of household in each pilot region. In Kenya, 6 rounds of data were collected at the time, until 2015, and in Ethiopia, 4 rounds of data were collected at the time of the pilot until 2015. In 2020 and 2022, followup surveys were collected from the original samples in Kenya and Ethiopia, respectively.

The panel survey collected information on the following topics:

- Household demographics
- Education and economic activities
- Health status of household members
- Livestock - accounting, loss, offtake, intake, birth, slaughter, milk production and sales
- Perception and expectations

- Livelihood activities and income
- Cash and in-kind transfers
- Other assistance
- Herd migration and satellite camps
- Consumption expenditures
- Livestock management expenditure
- Housing and amenities
- Assets - other livestock, land, productive assets
- Saving, lending and borrowing
- IBLI - contract, indemnity payouts, spending
- Coping strategies

6.2 Insurance firms' administrative data

We use administrative data from the insurance firms that sold insurance in the region since the original pilots. The administrative data include insurance purchase (the number of animals insured) and payout information.

7 Variable Construction

7.1 First stage outcome: cumulative insurance uptake

We use the insurance company's administrative data for insurance uptake. It is recorded for all sample households in every herding season and each type of animal – camel, cows, goats, and sheep. We use the cumulative insurance uptake over the initial three sales seasons[2], which will be measured by the number of seasons when a pastoralist purchased any IBLI policy.

7.2 Primary outcomes

7.2.1 Herd size and composition

Herd size is measured by the total number of animals a household herds, and the number of animals a household owns. We aggregate across animal types by cattle market-value equivalent.[3] We construct variables of herd composition – represented by the share of the value each animal type among the total value of livestock holding.

[2]Initial three sales seasons include 2010 January-February, 2011 January-February, and 2011 August-September in Kenya, and 2012 August-September, 2013 January-February, 2013 August-September in Ethiopia.

[3]Cattle market value equivalent is the average market value of each animal type relative to the cattle, using the pooled average prices observed from all purchases and all sold animals, by animal type and country from household survey panel data. The details of how we construct this value is described in the Appendix.

7.2.2 Total household income

Total household income is examined as a measure of material well-being of the household. We construct this measure by aggregating the income of a household from various income sources over the year. We winsorize the value at the 99th percentile to address the effect of extreme values. For comparability, US dollar is used as a currency.

7.2.3 Maximum years of education within a household

Human capital accumulation is a long-term outcome. If a household changed investments in human capital due to IBLI uptake, it could have an impact on the maximum years of education. We collected information of highest level of education completed by each household member, so we take the maximum of it to construct the variable.

7.3 Secondary outcomes

7.3.1 Herd management expenditure

Herd management expenditure is an important indicator of pastoral investment of a household. To measure this, we calculate the total annual expenditure on water, fodder, supplementary feeding, and veterinary expenses.

7.3.2 Annual milk income per livestock market-value equivalent

We use milk income per livestock market-value equivalent as a measure of productivity of livestock herding. IBLI was found to increase milk income per livestock market-value equivalent in the short-term. We aggregate the income per each animal unit from the milk sales throughout four sales seasons. For comparability, US dollar is used as a currency.

7.3.3 Livestock loss

Information on the number of animals lost due to various reasons (e.g., drought, diseases, livestock raid) was collected in the survey. We create a measure at the animal type, referring to the number of losses per animal type, as well as an aggregate measure by their market values using the pooled average prices observed from all purchases and all sold animals.

7.3.4 Distress sales of livestock (in response to indemnity payments)

This variable is constructed by the number of animals sold to cope with droughts. We aggregate the number of animals across different types by their market values using the pooled average prices observed from all purchases and all sold animals.

7.3.5 Share of children working full-time, part-time, and studying full-time

Children play important role in a household's livestock production. A previous study finds that IBLI increases children's participation in full-time schooling while decreasing part-time work. Using information on children's primary and secondary activities over the 12 month periods, we construct children's activity status ranging from full-time work, part-time work and schooling, and full-time schooling.

7.3.6 IBLI uptake in the past 12 months

IBLI uptake is recorded for all sample households in each type of animal – camels, cows, goats, and sheep. We examine both the extensive margin of whether or not the household purchased any IBLI policy, as well as the intensive margin corresponding to the number of animals insured of each type in Tropical Livestock Units (TLU).[4]

8 Empirical Strategy

8.1 Identification strategy

IBLI was first piloted in Marsabit County in Kenya in 2010 and then in the Borana Zone of Ethiopia in 2012. These original IBLI pilots included randomize premium discounts in the form of discount coupons that were distributed before each sales season. These discount coupons were not transferable, expired at the end of the immediate sales season, and provided discounts for purchasing IBLI in a range of 10-80 percent. The discount recipients and the amount of the discount were re-randomized each sales season.[5]

[4]Tropical Livestock Unit (TLU) is a unit to aggregate different types animals. 1 TLU = 0.7 Camel = 1 Cattle = 10 Sheep/goats.

[5]The design of the coupon distribution differed slightly across the countries. In Kenya, 60 percent of the sample households received coupons with discount rates ranging from 10 to 60 percent. In Ethiopia, 80 percent of the sample received coupons with discount rates ranging from 10 to 80 percent, in 10 percentage point interval. Coupons provide discount for up to first 15 TLU only.

Our empirical approach to causal identification relies on variation in IBLI purchases caused by the intervention – the discount coupons – that was both randomized at the household level and increased IBLI uptake during the pilot period.

Several studies have used the discount coupons to examine the impact of prices on purchase behavior (Jensen, Mude, and Barrett, 2018; Takahashi et al., 2016) and have used the discount coupons as instrumental variables (IVs) by which to test for the impacts of IBLI on household outcomes by estimating the local average treatment effects (LATE) and intent to treat (ITT) impacts (Janzen and Carter, 2019; Jensen, Barrett, and Mude, 2017; Matsuda, Takahashi, and Ikegami, 2019).

8.2 Attrition

We examine the effect of a product introduced about 10 years ago. The shortest time between the latest discount coupon distribution and the recent long-term follow-up survey is 5 years. Therefore, we evaluate how the attrited households differ from the households remaining in the sample, which is critical for interpreting the results.

To statistically evaluate the systematic difference of the attrited households, we estimate the following equation:

$$Attrition_{ijt=T} = \alpha + \beta X_{ijt=0} + \gamma_j + \epsilon_{ijt} \quad (1)$$

where $Attrition_{ijt=T}$ is an indicator variable equals to 1 if an individual household i in community j was interviewed at baseline (2009 in Kenya, 2012 in Ethiopia), but not at the latest round (2020 in Kenya and 2022 in Ethiopia). $X_{ijt=0}$ is the vector of characteristics of household i in community j at baseline. γ_j is the community fixed effects to control for the community-level commonalities. ϵ_{ijt} is the robust standard error – following Abadie et al. (2022) and Chaisemartin and Ramirez-Cuellar (2022), as the unit of randomization was individual households and we examine the treatment effects within our study sample.

In case of differential attrition, we will report Lee bounds of the treatment effect on the first stage outcomes following (Lee, 2009), and present the bound of the second stage using this bounds on the first stage outcomes.

We also evaluate whether the attrition was systematic across discount coupon receipt status. To this end, we estimate the following equation using Kenya, Ethiopia, and pooled sample separately:

$$\begin{aligned} \text{Attrition}_{ijt=T} =& \alpha + \Sigma_{t=1}^{6}(\beta_1^t \text{Received Coupon}_{ijt} + \beta_2^t \text{Discount Rate}_{ijt} \\ &+ Absent_{ijt}) + \gamma_j + \epsilon_{ijt} \end{aligned} \tag{2}$$

where Received Coupon$_{ijt}$ is an indicator equals to one if a household i in community j in sales season t received a discount coupon, Discount Rate$_{ijt}$ is the discount rate from the coupon in percentage term, defined as zero if the household did not receive any coupon. Since some households temporarily drop out of the survey for a few rounds and come back, we include $Absent_{ijt}$, an indicator denoting that the household was absent from the survey in sales season t. γ_j is community-fixed effects. ϵ_{ijt} is the robust standard error following Abadie et al. (2022) and Chaisemartin and Ramirez-Cuellar (2022). β_1^t would indicate whether coupon receipt status (=1 if discount rate is non-zero) in sales season t is correlated with attrition in the final round, and β_2^t shows whether the intensive margin of the discount – the non-zero discount rate is correlated with attrition in the final round.

Since we aim to analyze a long-term effect of IBLI, whether the cumulative number of coupon receipt, and the cumulative discount rate lead to differential attrition in the final sample is of interest. To find the effect of cumulative number of coupon receipts and the cumulative discount rate on the attrition, we estimate the Equation 3 using three samples again: Kenya, Ethiopia and pooled sample.

$$\begin{aligned} \text{Attrition}_{ijt=T} =& \alpha + \beta_1 \text{Cumulative N of Coupon Receipt}_{ij} \\ &+ \beta_2 \text{Cumulative Discount Rates}_{ij} + \gamma_j + \epsilon_{ij} \end{aligned} \tag{3}$$

where Cumulative N of Coupon Receipt$_{ij}$ the number of coupons received over the six sales seasons which ranged from 1 to 6 and Cumulative Discount Rates$_{ij}$ is the sum of discount rates the household received in all 6 sale seasons. All other variables are defined in the same way as the previous equations. β_1^t would indicate whether coupon receipt status (=1 if discount rate is non-zero) in sales season t is correlated with attrition in the final round, and β_2^t shows whether the intensive margin of the discount – the non-zero discount rate is correlated with attrition in the final round.

8.3 Balance checks

To verify the random assignment of the discount coupons to the sample households, we estimate the following equation separately for each variable of baseline characteristics that we would like to test for each round:

$$y_{ijt} = \alpha + \beta_1 \text{Received Coupon}_{ijt} + \gamma_j + \epsilon_{ijt} \tag{4}$$

where y_{ijt} denotes a characteristic of a household i in community j in sales season t, and the other variables are the same as previous equations.

We will report the coefficient and p-value for each treatment indicator for each balance variable. We will also report the statistic for joint significance of the balance variables and its p-value, as well as normalized difference. Normalized difference is a scale-invariant measure of the size of the difference, which is calculated by the following equation:

$$\text{Normalized Difference} = \frac{\bar{X}_{treatment} - \bar{X}_{control}}{\sqrt{(s^2_{treatment} + s^2_{control})/2}} \tag{5}$$

where $\bar{X}$ is a mean and s is a standard deviation of a variable.

We will use the rule of thumb of 0.25 as suggested by Imbens and Rubin (2015) to evaluate whether the difference is small.

We use the following variables that were collected at the survey round before the randomization was conducted to test balance: Age of the household head, male-headed households, head's completed years of education, adult equivalent in a household, dependency ratio[6], cattle market value equivalent of the herd size, and monthly household income per capita, and land size. The choice of these variables follows that of Jensen, Barrett, and Mude (2017) and Takahashi et al. (2016).

[6]Dependency ratio is the ratio of dependents – people younger than 15 or older than 64 – to the working-age population, those ages 15-64.

8.4 Instrument variable

8.4.1 Base models

We use the randomly distributed discount coupons to estimate the Local Average Treatment Effect (LATE) of IBLI purchases between 2010 and 2015 on outcomes many years later—October 2020 in Kenya and January 2022 in Ethiopia.

Equation (6)-(10) describes the outcome and IV equations. We use an Analysis of Covariance (ANCOVA) estimation model (Equation (6)) to estimate the LATE of IBLI purchases on our outcomes of interest, where we instrument for cumulative IBLI uptake using the total number of coupons received by households in the first three sales seasons (Equation 7).[7]

Both IBLI purchases (Equation 8) and discount coupons (Equation 9) are aggregated into a simple count of the number of seasons in which the household purchased coverage ($IBLI_{i,u}$) or received a discount coupon ($Discount_{i,u}$). The LATE estimate is therefore restricted to assessing the impacts of purchases that took place in response to the discount coupons and therefore only during periods that the discount coupons were distributed (Equation 10). Note that in Kenya IBLI was not sold during the August/September 2010 or the January/February 2012 seasons due to administrative issues, and there were no discount coupons distributed during those seasons. Note that we use discount coupons of the initial three seasons in both countries as instruments instead of all seasons. This choice is made to maximize the predictive power of the first stage. We present effective F-statistics from Olea and

[7]The first three sales seasons are January-February 2010, January-February 2011, and August-September 2011 in Kenya, and August-September 2012, January-February 2013, and August-September 2013 in Ethiopia.

Pflueger (2013) as an indicator of the predictive power of the first stage.

$$y_{i,u,j,t=T} = \beta^0 + \beta^1 y_{i,u,j,t=0} + \beta^2 x_{i,u,j,t=0} + \beta^3 C_{i,u,j} + \beta^{LATE} \widehat{IBLI}_{i,u,j} + \gamma_j + \epsilon_{i,u,j,t=T} \quad (6)$$

$$IBLI_{i,u,j} = \alpha^0 + \alpha^1 y_{i,u,j,t=0} + \alpha^2 x_{i,u,j,t=0} + + \alpha^3 C_{i,u,j} + \alpha^3 Discount_{i,u,j} + \gamma_j + \mu_{i,u,j} \quad (7)$$

$$IBLI_{i,u,j} = \sum_{t \in [C]} I^{IBLI}_{i,u,j,t} \text{ where } I^{IBLI}_{i,u,j,t} = 1 \text{ if } IBLI_{i,u,j,t} > 0 \quad (8)$$

$$Discount_{i,u,j} = \sum_{t \in [C]} I^{Discount}_{i,u,j,t} \text{ where } I^{Discount}_{i,u,j,t} = 1 \text{ if } Discount_{i,u,j,t} > 0 \quad (9)$$

$$C = \begin{bmatrix} 2010JF, 2011JF, 2011AS \text{ in Kenya} \\ 2012AS, 2013JF, 2013AS \text{ in Ethiopia} \end{bmatrix} \quad (10)$$

where $y_{i,u,j,t}$ is outcome y for individual i, who lives in index unit u, community j, in period t.[8] In this case, $t = 0$ during the period before insurance was first sold in u, $t = 1$ in the first period in which insurance was sold in u, and $t = T$ in the period of analysis. $y_{i,u,j,t=0}$ and $x_{i,u,j,t=0}$ represents the household's initial conditions in the period before insurance was sold in u. $C_{i,u,j}$ is a vector of discount coupon receipt in

[8] Community is 16 sublocations in Kenya and 17 kebeles in Ethiopia.

the later three sales seasons.

In addition to the coefficient, we report the robust standard error – following Abadie et al. (2022) and Chaisemartin and Ramirez-Cuellar (2022). We also report "standard" p-value for $IBLI_{i,u}$ for each outcome variable and sharpened False Discovery Rate (FDR)-adjusted q-values correcting across dependent variables within each family of outcomes as listed above, as a multiple hypothesis testing (Anderson, 2008).

8.5 Heterogeneous Effects

We will estimate heterogeneous treatment effects across baseline variables by augmenting Equation (6) and (7) to include the baseline variables of interest and a vector of interactions between the vector of treatment indicators and the baseline variables of interest. The baseline variables of interest include country, herd tercile, and the gender of the household head. The estimating equations for heterogeneous effects are as follows:

$$\begin{aligned} y_{i,u,j,t=T} =& \beta^0 + \beta^1 y_{i,u,j,t=0} + \beta^2 x_{i,u,j,t=0} + \beta^3 C_{i,u,j} + \beta^4 H_{i,u,j,t=0} + \beta^{LATE} \widehat{IBLI}_{i,u,j} \\ &+ \beta^{Hetero-LATE} \widehat{IBLI_{i,u,j} \times} H_{i,u,j,t=0} + \gamma_j + \epsilon_{i,u,j,t=T} \end{aligned} \tag{11}$$

$$\begin{aligned} IBLI_{i,u,j} =& \alpha^0 + \alpha^1 y_{i,u,j,t=0} + \alpha^2 x_{i,u,j,t=0} + \alpha^3 C_{i,u,j} + \alpha^4 Discount_{i,u,j} + \alpha^5 H_{i,u,j,t=0} \\ &+ \alpha^6 Discount_{i,u,j} \times H_{i,u,j,t=0} + \gamma_j + \mu_{i,u,j} \end{aligned} \tag{12}$$

$$IBLI_{i,u,j} \times H_{i,u,j,t=0} = \alpha^0 + \alpha^1 y_{i,u,j,t=0} + \alpha^2 x_{i,u,j,t=0} + \alpha^3 Discount_{i,u,j} + \alpha^4 H_{i,u,j,t=0} + \alpha^5 Discount_{i,u,j} \times H_{i,u,j,t=0} + \gamma_j + \mu_{i,u,j} \quad (13)$$

where variables, estimated coefficients and fixed effects are as specified in Equation 6 and 7. We add interactions between $Discount_{i,u,j}$ in the first stage and the $IBLI_{i,u,j}$ in the second stage and the specific heterogeneity variable $H_{i,u,j,t=0}$ in which we are interested.

For country, $H_{i,u,j,t=0}$ is an indicator equals to one if a pastoralist is surveyed in Ethiopia. For the herd tercile, $H_{i,u,j,t=0}$ is two indicators equal to one if the household is from the 1st and 2nd tercile in the initial round. Lastly, for the gender of the household head, it is an indicator equals to one if the head of the interviewed household is female.

References

Abadie, Alberto, Susan Athey, Guido W Imbens, and Jeffrey M Wooldridge (2022). "When Should You Adjust Standard Errors for Clustering?" *The Quarterly Journal of Economics* 138(1), 1–35.

Anderson, Michael L. (2008). "Multiple Inference and Gender Differences in the Effects of Early Intervention: A Reevaluation of the Abecedarian, Perry Preschool, and Early Training Projects." *Journal of the American Statistical Association* 103(484), 1481–1495.

Chaisemartin, Clément de and Jaime Ramirez-Cuellar (2022). *At What Level Should One Cluster Standard Errors in Paired and Small-Strata Experiments?* SSRN Scholarly Paper. Rochester, NY.

Imbens, Guido W. and Donald B. Rubin (2015). *Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction.* Cambridge: Cambridge University Press. ISBN: 978-0-521-88588-1.

Janzen, Sarah A. and Michael R. Carter (2019). "After the Drought: The Impact of Microinsurance on Consumption Smoothing and Asset Protection." *American Journal of Agricultural Economics* 101(3), 651–671.

Jensen, Nathaniel D., Christopher B. Barrett, and Andrew G. Mude (2017). "Cash transfers and index insurance: A comparative impact analysis from northern Kenya." *Journal of Development Economics* 129, 14–28.

Jensen, Nathaniel D., Andrew G. Mude, and Christopher B. Barrett (2018). "How basis risk and spatiotemporal adverse selection influence demand for index insurance: Evidence from northern Kenya." *Food Policy* 74, 172–198.

Lee, David S. (2009). "Training, Wages, and Sample Selection: Estimating Sharp Bounds on Treatment Effects." *The Review of Economic Studies* 76(3), 1071–1102.

Matsuda, Ayako, Kazushi Takahashi, and Munenobu Ikegami (2019). "Direct and indirect impact of index-based livestock insurance in Southern Ethiopia." *The Geneva Papers on Risk and Insurance - Issues and Practice* 44(3), 481–502.

Olea, José Luis Montiel and Carolin Pflueger (2013). "A Robust Test for Weak Instruments." *Journal of Business & Economic Statistics* 31(3). Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/00401706.2013.806694, 358–369.

Takahashi, Kazushi, Munenobu Ikegami, Megan Sheahan, and Christopher B. Barrett (2016). "Experimental Evidence on the Drivers of Index-Based Livestock Insurance Demand in Southern Ethiopia." *World Development* 78, 324–340.

Appendix

Livestock herd aggregation

It is sometimes necessary to aggregate livestock herds that contain more than one animal type into a single herd size. This aggregation requires transforming animals of different types, ages, sexes and condition into a single comparable unit. The Tropical Livestock Unit (TLU) is one such unit that is commonly used. The transformation of animals to TLUs is usually done according to a series of weights according to the weight of the average adult animal, which is a proxy for the biomass needs of the animal. In this case, our interest in total herd size or herd size composition is as a productive asset or as a store of wealth. Therefore, rather than use a transformation that is based on weight, we will aggregate across animal types by their market value.

While we cannot observe the market value of a herd directly, we could use market prices to approximate herd values. Unfortunate, there are no consistent and publicly available livestock market prices from the study regions and export prices almost surely reflect large variation between animals and market locations in the costs of purchasing, transporting, fattening and processing animals for export. The local price data we were able to locate include the following.

1. The National Drought Management Agency (NDMA):
    - Data for Marsabit and neighboring counties in Kenya.
    - Includes some historic data but data are not available, only interpretable from figures.
    - Price data are collected from marketed animals, which are unlikely to be identical in value to the average animal in an individual's herd.
2. Livestock Market Information System (LSMIS):
    - Data are available for counties near Marsabit.
    - Data are not available but figures showing trends from 2020-2022 can be used to estimate averages.
    - Price data are collected from marketed animals, which are unlikely to be identical in value to the average animal in an individual's herd.
3. ILRI longitudinal household surveys: Kenya, Ethiopia

- Data available in several years from the exact households that are used in this study.
- Price data are only available for purchased and sold animals, which are unlikely to be identical in value to the average animal in an individual's herd.

Given that all three sources identified suffer from the same prospective selection issue, and the household survey is the only source for longer-term price data in Ethiopia, we choose to use the ILRI household survey panel data to calculate value. Because we understand that livestock and market conditions can fluctuate widely season-by-season, and we are unable to distinguish between the two, we use the pooled average prices observed from all purchases and all sold animals, by animal type and country, as the value of each animal type. The values used are as follows.

Table A1: Livestock Herd Aggregation

	(1)	(2)	(3)	(4)	(5)	(6)
	Marsabit, Kenya			**Borana, Ethiopia**		
	KES	Cattle Equivalent	Data Rounds	Birr	Cattle Equivalent	Data Rounds
Camel	25,132	1.6	1-7	7,447	2.5	1-4
Cattle	15,617	1.0	1-7	3,023	1.0	1-4
Sheep	1,515	0.1	7			
Goats	1,561	0.1	7			
Sheep or Goat	2,308	0.15	1-6	484	0.16	1-4