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**AN AGGREGATE ANALYSIS OF THE IMPACT OF INDEX BASED  
LIVESTOCK INSURANCE ON PASTORALISTS IN KENYA**

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Actuarial Science in Strathmore University**

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**November, 2017.**

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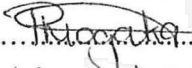
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## **ABSTRACT**

The purpose of this study was to quantify the effects of Index Based Livestock Insurance in Kenya on income generation and welfare enhancement of pastoral households. Index-Based insurance attracts attention as a potentially effective tool for reducing vulnerability of agricultural households in developing countries. However, previous literature has assumed away how household intertemporal behavior and welfare would change by reduced production risk and shock due to index-based insurance. The paper employed the endogenous treatment regression model in order to quantify the effects of Index Based Livestock Insurance on an aggregate level. The study finds that insurance provision induces pastoralists to shift production towards higher return but higher risk breeds of livestock. The results support the view that financial innovation can mitigate the real effects of uninsured production risk.

## **Keywords**

Poverty traps, Covariate risk, Index, Moral hazard, Adverse selection, Weather shocks

## **Abbreviations**

IBLI	Index Based Livestock Insurance
FAO	Food and Agriculture Organization of the United Nations
NDVI	Normalized Difference Vegetation Index
TLU	Tropical Livestock Units
USAID	United States Agency for International Development

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## CHAPTER 1: INTRODUCTION

### 1.1 Background of the study

Weather is a key source of income risk, particularly in emerging market economies. These are areas characterized by the in-availability of financial market instruments that compounds the shortcomings of ineffectual and inadequate risk management and coping strategies. A plausible solution to this problem is the ability of financial markets to enable individuals to access insurance, consequently allowing them to access credit. The unfavorable effects of uninsured risks need to be mitigated so as to cut short its contribution to the enhancement of poverty traps.

The unfavorable effects of weather shocks are quite substantive as compounded by their inability to be insured against. Fluctuations in weather do present detrimental effects on the wellbeing of households in developing countries. From an aggregate level perspective, adverse weather slows down economic growth. For example, (Dell, Jones, & Olken, 2012) report negative effect of rising temperature on poor countries' economic growth. Production losses that are often as a result of the adverse weather conditions have the effect of restraining households in the circle of poverty.

Insurance makes available to households an alternative risk management tool that may reduce the use of costly coping strategies. This is achieved when insurance transforms the households' ability to cope with weather shocks when they have occurred. Insurance may also alter the optimal behavior of households before the shocks actually occur. Insurance offers an alternative means of coping with negative shocks, allowing smoothing of consumption and nutrition, as well as avoidance of costly asset depletion (Dercon, 2008). We have recently witnessed the enactment of promising market-based interventions aimed at mitigating weather related agricultural risk. Index Based Insurance products represent a promising option for managing climate related risk.

Index Based insurance holds considerable appeal for both commercial and development purposes because it allows for management of covariate risk, meaning that neighboring households suffer similar shocks. Index insurance resolves the problem of moral hazard (lack of incentive to guard against risk when one is insured) but however induces basis risk, which arises when the index measurements do not match an individual insured's

actual losses. These financial instruments make indemnity payments based on realizations of an underlying index that is based on some objectively measured random variable- relative to a pre-specified threshold, the “strike” (Barnett B. J., 2008). Index Based Livestock Insurance compensates for livestock loss. However unlike traditional insurance, it only compensates for covariate herd losses that are objectively and transparently observable. Since the indemnity is not based on individual claims, insurance providers, as well as the insured, only need to monitor the index to know when the payments are due. This greatly reduces transaction costs associated with monitoring and loss verification, whilst greatly minimizing moral hazard.

Since 2010, pastoralists in northern Kenya have had the opportunity to purchase a novel index-based insurance contract to protect against livestock mortality losses due to drought. The IBLI index insurance contract uses satellite based NDVI (normalized difference vegetation index) measures of available vegetative cover to predict average livestock mortality experienced by local communities. These data are publicly available in near-real time and are objectively verifiable. The IBLI index has been shown to be highly correlated with actual livestock mortality experienced by pastoralists in the region (Carter, Galarza, & Boucher, 2007) (Chantarat S. M., 2010).

Households choose the number of livestock they wish to insure, with the contract expressed in tropical livestock units (TLU), so that a single annual contract accommodates the various livestock species common in the region: cattle, goats, sheep and camels. The premium households pay depends on the risk associated with the geographic region in which they live. Insured households receive a payout at the end of each dry season (at the beginning of October and again early in March) if the predicted average livestock mortality rate reaches 15%, with the payout equal to the value of all predicted average losses greater than 15%. In October- November 2011, a harsh drought swept across the Horn of Africa, and the first IBLI payouts were made to households who had purchased insurance earlier in the year.

Despite the numerous plausible advantages that index insurance offers, it is important to highlight that it however does not resolve the risk-related shortcomings of rural financial markets. Most importantly, by its construction, index-based insurance only covers a fraction of the risks faced by farming households, leaving them exposed to residual uninsured, or basis risk, which arises when the index measurements do not match an individual insured's actual losses (Carter et al., 2007). A key empirical question then is whether provision of the partial protection offered by index insurance will suffice to relax demand constraints to borrowing and empower small holders to pursue more entrepreneurial strategies. Objectively, on the supply side, we might ask whether index insurance suffices to relax the reluctance of rural microfinance lenders to carry a larger agricultural portfolio, (Carter et al., 2007).

### **1.2 Motivation of the study**

Despite the many resources devoted to promote Index Based Livestock Insurance, there has been little research to quantify its potential benefits. The economic literature on index based agricultural insurance has not studied the dynamic effects of index based agricultural insurance on household welfare enhancement and future income generation in the long run. Research conducted in the previous years has either been a prior or post assessment of the impact of IBLI.

Prior models assume away possible indirect benefits of IBLI, such as its potential to crowd in finance for ancillary investment and growth. If IBLI crowds in credit access, it may alter the growth trajectory and the critical herd size threshold, opening up the possibility that IBLI benefits the least well-off pastoralists as well (Sommarat Chantarat. Andrew G. Mude, 2009). Due to moral hazard and adverse selection problems, conventional insurance has proved financially inefficient. IBLI however offers a solution to this, by being moral hazard and adverse selection proof. Hence, begging the empirical question of whether the provision of IBLI will suffice to relax the borrowing constraints that pastoralists face and empower households to pursue more entrepreneurial strategies.

The foregoing implies that there is a need for a closer look at IBLI provision in Kenya and how effective it is in relaxing the borrowing constraints that pastoralists face and

consequently empower households to pursue more entrepreneurial strategies. This study is also informed by the fact that prior studies on this area were prior or post assessments of the impact of IBLI as opposed to striking a balance between the two impact valuation techniques. The study also seeks to identify a model that correctly predicts the impact of IBLI on pastoral households' welfare, income generation and credit seeking behavior.

### **1.3 Research Objectives**

The overall objective of this study is to assess the impact of Index Based Livestock Insurance on Kenyan pastoralist households' income. Specifically, the study aims to:

- 1) Determine the impact of IBLI on its ability of enhancing the credit seeking behavior of pastoralists households.
- 2) Establish the overall effectiveness of IBLI in making households more self-sufficient: relying less on food aid or assistance programs.
- 3) Identify a model that can be used to assess the impact of index insurance on households' welfare development and future income generation.

### **1.4 Research Questions**

The following questions shall guide this study:

- 1) Does IBLI induce pastoral households to seek credit and consequently enhance the future income generation?
- 2) How does IBLI contribute to household self-sufficiency?
- 3) Is it possible to create a model that assesses the impact of index insurance on welfare development and future income generation?

### **1.5 Value of the study**

The significance of this study is to inform the policy debate on impact evaluation and also to contribute to the existing literature on the effectiveness of index insurance. This contribution is achieved by focusing on aggregate level analysis of the impact of IBLI on pastoralists. The study seeks to make known to stakeholders what works or does not

work. This will be of importance in the progressive implementation of similar projects or programs (index insurance) among beneficiary communities. The study may also prove significant to credit lenders (financial institutions) as they assess the credit worthiness of pastoralists who have often been labeled as high risk borrowers, based on their collateral assets: livestock, which now has an insurance backing.



## CHAPTER 2: LITERATURE REVIEW

### 2.1 Introduction

There has been a lot of literature in the field of knowledge of index insurance and its impact. In this respect, this chapter shall analyze work done by a number of different authors on index insurance, its impact on household welfare and its credit pooling mechanism as well as models used to explain its impact.

### 2.2 What is Index Insurance and what is its purpose?

What is index insurance? Like typical insurance, IBLI compensates for livestock losses. But unlike traditional insurance, it only compensates for the covariate herd losses that are objectively and transparently observable. In the case of Northern Kenya, the increasingly popular remotely sensed Normalized Differential Vegetation Index (NDVI), an indicator of vegetative cover widely used in drought monitoring programs in Africa, is used to predict covariate herd mortality in a particular location, meaning that the neighboring households suffer similar shocks. An objectively measured herd mortality index constructed from such strong predictive relationship is then used to trigger IBLI's indemnity payments for the insured in such coverage area.

Proponents of weather index insurance argue that it is a strategy to reduce risk, improve productivity, and increase welfare among poor households in developing countries. For example, Cole et al (2012) states that index insurance can provide agricultural households with a mechanism to mitigate risk formally, which in turn may allow them to make riskier, more profitable investment decisions. It is also argued that provision of weather index insurance encourages adoption of technologies. According to Miranda & Farrin (2012), weather-based index insurance has been offered as an alternative method for increasing uptake of agricultural technology. Index Insurance products allow the agricultural production system to fundamentally shift who bears weather risk by shifting its burden towards globally diversified reinsurers. If producers are 'risk rationed' in their use of credit (Boucher et al XX), then lifting weather risk from their shoulders can crowd in demand for credit, and holds the promise of resulting in first-order increases in average productivity.

At the international level, weather index insurance has already been identified as a means to end the poverty trap of rural poor in developing countries and several resources have been put to promote it. In recent years, there has been excitement among academia as well as practitioners about the prospects of introducing weather index insurance to manage small holder farmers' risk in developing countries (Farrina & Mirandab, n.d.) (Awel and Azomahou, 2014). Within a decade, there has been numerous weather index insurance pilot programs in Ethiopia, Kenya, India and China (Janzen & Carter, 2013)

It is worth noting however that index insurance is partial insurance: even standard demand theory makes equivocal predictions about the relationship between parameters such as risk aversion or background risk and the demand for partial insurance. The possibility that index may fail to pay out in some loss states means that the paying of an index insurance premium increases the variance in income (Clarke 2013).

### 2.3 Theoretical Literature

This section provides a literature review of some of the theories that have been brought forward to analyze the impact of IBLI contracts. Consequently, I purpose to establish a causal relationship. According to Wooldridge (2010), the organizing principle of modern approach to program evaluation is the counterfactual framework pioneered by Rubin (1974).

#### 2.3.1 The Rubin Causal Model/The Counterfactual Setting Framework

The intuition behind the Rubin causal model is that each individual (or other agent) has two potential outcomes, with treatment and without treatment. The treatment effect on an individual is the difference between the individual's state with the treatment and the state without the treatment. Mathematically, let  $D_i = \{0,1\}$  represent a binary treatment, and  $Y_i$  be the outcome of interest from the treatment.

$$\text{Potential outcome} = \begin{cases} Y_{1i} & \text{if } D_i = 1 \\ Y_{0i} & \text{if } D_i = 0 \end{cases}$$

The observed outcome  $Y_i$  can be written in terms of the potential outcome as follows:

$$Y_i = \begin{cases} Y_{1i} & \text{if } D_i = 1 \\ Y_{0i} & \text{if } D_i = 0 \end{cases}$$

$$Y_i = Y_{0i} + (Y_{1i} - Y_{0i}) D_i$$

In this form,  $Y_{1i} - Y_{0i}$  is the causal effect of the treatment for an individual. But in practice or in equity, we never get to observe both potential outcomes for an individual. So, in order to observe the effect of treatment, we have to compare the average outcome of those who took part in the treatment with that of those who did not take part in the treatment.

Naively comparing the averages by treatment status gives us an indication of potential outcomes although not necessarily what we are interested in. This comparison of average outcomes conditional on treatment can be linked to the average treatment effect through the following equation:

$$\begin{aligned} E[Y_i | D_i = 1] - E[Y_i | D_i = 0] \\ = \{E[Y_{1i} | D_i = 1] - E[Y_{0i} | D_i = 1]\} + \{E[Y_{0i} | D_i = 1] - E[Y_{0i} | D_i = 0]\} \end{aligned}$$

The term:

$E[Y_{1i} | D_i = 1] - E[Y_{0i} | D_i = 1]$ , can be written as  $E[Y_{1i} - Y_{0i} | D_i = 1]$  and it is the average effect of the treatment on those who took part in the treatment (ATET). This term captures the average difference between the observed outcomes of the treated,  $E[Y_{1i} | D_i = 1]$ , and what would their observed outcomes be if they had not been treated,  $E[Y_{0i} | D_i = 1]$ . This is exactly what we intend to measure. However, the observed difference in outcomes between the treatment and non-treatment groups comes along with,

$E[Y_{0i} | D_i = 1] - E[Y_{0i} | D_i = 0]$ . This is the difference in average expected outputs between those who were treated and those who were not treated. This difference is called “self-selection bias”. This means that individuals select themselves into treatment groups, and their decisions maybe related to the benefits of or gain from treatment. Self-selection bias also means that, observed differences between treated and untreated groups could be due to other factors that determine selection into treatment group.

The natural solution to self selection bias is to do randomization of treatment such that

the treatment variable is independent of the potential outcome, and every element in the population could potentially be in either the treatment group or untreated group. Several methods have been proposed to address the selection bias in empirical research where randomization is often not done.

### ***2.3.2 Endogenous Treatment Regression Model***

The endogenous treatment- regression model also called endogenous binary-variable model or endogenous dummy-variable model is a linear potential-outcome model that allows for a specific correlation structure between the un-observables that affect potential outcomes. Heckman (1978) brought this model to the modern literature. Maddala (1983) also worked on the maximum likelihood and two-step estimation procedures, reviewed some empirical applications of this model, and describes it as a constrained endogenous-switching model. Cameron and Trivedi (2005) and Wooldridge (2010) discuss the endogenous treatment-effects model and link it to recent work.

Cameron and Trivedi (2005) specify the conditional means in the potential outcome equations as linear, and then complete the model by adding a participation (binary) decision for  $D_i$ .

Mathematically,

$$y_{1i} = x_i' \beta_1 + \mu_{1i}$$

$$y_{0i} = x_i' \beta_0 + \mu_{0i}$$

$$D_i^* = z_i' \gamma + \varepsilon_i$$

Where,  $D_i$  is a latent variable such that

$$D_i = \begin{cases} 1, & \text{if } D_i^* > 0, \\ 0, & \text{if } D_i^* \leq 0. \end{cases}$$

The underlying assumption is that  $E[\mu_1|x, z] = E[\mu_0|x, z] = 0$ . It is also assumed that the triple errors  $(\mu_{1i}, \mu_{0i}, \varepsilon_i)$  are jointly multivariate normal distributed with zero mean and

covariance matrix given by

$$\Sigma = \begin{pmatrix} \sigma_{11} & \sigma_{10} & \sigma_{1\epsilon} \\ \sigma_{10} & \sigma_{00} & \sigma_{0\epsilon} \\ \sigma_{1\epsilon} & \sigma_{0\epsilon} & \sigma_1 \end{pmatrix}$$

The average treatment effect on the treated (ATET) then is given by

$$Y_{1i} - E[y_{0i} | D_i = 1] = y_{1i} - x_i' \beta_0 + (\sigma_{0\epsilon} - \sigma_{1\epsilon}) \frac{\phi(z_i \gamma)}{\Phi(z_i \gamma)},$$

which may also be written as:

$$[y_{1i} | D_i = 1] - [y_{0i} | D_i = 1] = x_i' (\beta_1 - \beta_0) + (\sigma_{0\epsilon} - \sigma_{1\epsilon}) \frac{\phi(z_i \gamma)}{\Phi(z_i \gamma)},$$

where  $(\sigma_{0\epsilon} - \sigma_{1\epsilon}) \frac{\phi(z_i \gamma)}{\Phi(z_i \gamma)}$  is the selection effect.

The model can then be estimated by maximum likelihood or two-step semi-parametric procedure.

### ***2.3.3 Doubly-robust estimation- Inverse Probability Weighted Regression Adjustment (IPWRA)***

This estimation procedure is one of many that are based on the assumption that selection into treatment is based on observables, and that controlling for such observable covariates will enable us estimate the true effect of treatment. It is a combination of regression adjustment (RA) and inverse-probability weights (IPW). Wooldridge (2010) suggests that combining regression adjustment and propensity score methods as in this case, provides some robustness to misspecification of the parametric models, because it only requires either the conditional mean model (outcome equation) or the propensity score model (treatment equation) to be correctly specified, not both.

When treatment and potential outcomes are allowed to be correlated, an assumption is needed to identify treatment effects. Rosenbaum and Rubin cited in Wooldridge (2010) introduced an assumption which they call ignorability of treatment given observed

covariates, treatment and potential outcomes are independent.

Wooldridge (2010) also says that, once ignorability of treatment holds, the overlap assumption is required to fully identify the unconditional effects of treatment. The overlap assumption means that, for any setting of the covariates in the assumed population, there is a chance of seeing units in both the control and treatment groups.

The estimation is done according to the procedure outlined by Wooldridge (2010), and was implemented by Awel and Azomahou (2014).

Mathematically, it is written as;

$$\min \alpha_1, \beta_1 \sum_{i=1}^N (y_i - \alpha_1 - \beta_1 x_i) / p(x_i, \hat{y}) \quad \text{if } I_i=1$$

$$\min \alpha_0, \beta_0 \sum_{i=1}^N (y_i - \alpha_0 - \beta_0 x_i) / (1 - p(x_i, \hat{y})) \quad \text{if } I_i=0$$

$$ATE_{ipwra} = N^{-1} \sum_{i=1}^N [(\hat{\alpha}_1 - \hat{\beta}_1 x_i) - I_i (\hat{\alpha}_0 - \hat{\beta}_0 x_i)],$$

Where  $(\alpha_i, \beta_i)$  are the estimated inverse probability weighted parameters for  $I = 0$  and  $I = 1$  respectively and  $p(x_i, \hat{y})$  is the estimated propensity scores.

## 2.4 Empirical Literature

The following section provides a review of some of the empirical literature that has been done in the areas of the impact of IBLI on households' welfare, their risk taking enhancements and the overall effectiveness of IBLI contracts.

### 2.4.1 IBLI and Credit Market Depth.

As mentioned in the background of this study, there are a number of schools of thought when it comes to Index Insurance and Credit Market deepening debate. One school of thought asserts that there is a positive impact of Index Insurance on credit market deepening. The other school of thought disputes this by saying that Index Insurance has

a negative impact on credit market deepening. Yet another school of thought asserts that the Index Insurance-Credit Market deepening is a contingent one, that is the impact of Index Insurance is positive in the presence of certain factors such as interlinked credit, and negative otherwise.

Interlinking is a concept that has theoretical support both on the supply side and the demand side. On the supply side, lenders may face an unacceptable level of correlated risk in agricultural credit if this portfolio is subjected to a large covariate risk from weather. Index insurance allows some of this systematic risk to be passed onto international reinsurers (Carter et al., 2016). An explicitly interlinked contract effectively makes the bank the beneficiary on the insurance policy, and hence removes the risk that the farmer might receive a payout but not use it to pay back the bank, (Shukri Ahmed, 2016) On the demand side, interlinking provides potential solutions to several of the key factors that have been put forth as depressors of demand. Impatient individuals will desire credit but dislike insurance, where costs must be borne up front in the form of premium payments, and benefits are probabilistic and experienced far in the future.

One of the first studies on the role played by index insurance to crowd in credit supply and demand was by Carter et al. (2007). Herein, the authors explored the potential impacts that index insurance schemes posed on producers' output and income and on 'crowding-in' credit supply. This study analyzed two index insurance schemes, one based on weather index and the other was based on measured average yields. The author points out that although these index insurance products do not protect the farmer from all risks, their econometric analysis (which was based on data on irrigated rice production in the Lambayeque valley on the north coast of Peru) showed that they could have substantial value to the producer and could also crowd-in credit supply from lenders reluctant to carry too much covariant risk in their loan portfolio,(Carter et al., 2007). Carter et al., (2007) further went on to simulate farmers' loan repayment behavior to evaluate potential impacts on lenders. They found out that both schemes reduce loan default and increase loan portfolio return by 4 to 6 percent, depending on the type (measured or weather) of area based scheme used. The authors consequently based on their findings concluded that indeed index insurance positively impacts both the supply

and demand for credit.

Gine and Yang (2008) examine the impact of rainfall insurance on the demand for formal credit in Malawi. Their research design randomizes whether loans made by a microfinance institution are bundled with insurance. The authors find the counter-intuitive result that insurance reduced the demand for credit. They attribute this result to the fact that the credit contract already provides some insurance via limited liability so that bundling insurance with the loan implies an increase in the interest rate without any additional insurance.

Dean Karlan (2014) asserts that binding credit market constraints and incomplete insurance can limit investment in activities with high expected profits. The authors' finding on an experiment conducted in Ghana in which farmers were randomly assigned to receive cash grants, grants of or opportunities to purchase rainfall index insurance, or a combination of the two, found that demand for index insurance was strong and that insurance leads to significantly larger agricultural investment and riskier production choices in agriculture. They also allude that both investment patterns and the demand for index insurance are consistent with the presence of important basis risk associated with the index insurance, imperfect trust that promised payouts would have been delivered and overweighting recent events.

Farrina & Mirandab (2014) also provide a view of the impact of Index Insurance on credit market deepening. The authors numerically solve the Bellman equation under four scenarios using the base parameterization, varying the interest rate on credit across simulations: this is done in order to assess the effect that insurance has on rural credit market. Using different specifications, the authors find that target profit levels could be obtained under lower interest rates in the contingent credit regime, where credit and insurance are simultaneously offered. The authors also found out that borrowing is spurred by lower interest rates, with loan uptake at above 45% for contingent credit; the borrowing rate decreased to less than 25 when no insurance is available. The paper notes that its findings are crucial when assessing bank sustainability. Considered was a case in which a bank desired a certain profit level, consequently it may opt out of operating in areas where only low profits are realized. Households would therefore have no access to

credit, possible effects including households resorting to extreme coping mechanisms while trading off higher income opportunities.

#### ***2.4.2 IBLI on welfare enhancement, production and investment decisions***

There are recent studies that examined the impact of weather index insurance on welfare enhancement, production and investment decisions. Worth noting is that Index insurance's impact on welfare has been ambiguous so far as evidenced by literature.

De Nicola (2010) estimated a dynamic stochastic optimization model to assess the impact of weather-based insurance on consumption, investment and welfare for farmers in Malawi. The study found that weather-based insurance had the potential to provide substantial welfare gains in terms of an almost 17% increase in consumption. In a model extension, the study showed that weather-based insurance allowed for the adoption of riskier but more productive improved seeds further improving farmers' welfare gains arising from increases in farmers' incomes. The study did not however show how much the income had increases due to weather based insurance.

Cai (2012) used both difference-in-difference and triple difference estimation to assess the impact of agricultural insurance program on household production, borrowing and saving behavior in China. Introducing insurance was found to increase the production area of insured crops by about 20%. It also decreased production diversification. Furthermore, the study found that providing insurance raised credit demand by 25% but decreased household savings by more than 30%. However, there was no direct effect on household income reported. In a similar study, Liu et al. (2013) studied livestock insurance in China and find evidence that insured livestock farmers increased their stock by purchasing more piglets for fattening. Shapiro (2009) also finds that weather insurance provision encourages farmers to use more expensive capital inputs and adopt different technologies.

Janzen and Carter (2013) examined the impact of micro-insurance on consumption smoothing and asset protection in Kenya. The authors main research question was dubbed: can insurance transfer risk in a way that it reduces the need for households to rely on costly coping strategies that undermine future productivity. They find that

insured households are 36 percentage points less likely to anticipate drawing down asset, and 25 percentage points less likely to anticipate reducing meals upon receipt of insurance payout. They however note that empirical evidence of a poverty trap in this setting suggests that these average impacts may mask a heterogeneous behavioral response and subsequent heterogeneous impacts of insurance. The authors suggest that insurance can help protect assets during crisis, without having the deleterious effect on human capital investments.

Awel and Azomahou (2014) assessed the impact of weather index on technology adoption, productivity and welfare at the household level of insured farmers in Ethiopia. The study employed different approaches to address the selection bias problem. First, a matching technique was used assuming the selectivity bias was due to observable characteristics. Second, the inverse probability weighted regression (IPWR) and IV approach were applied assuming that the selection bias was due to unobservable characteristics. The study confirmed a positive benefit of insurance in terms of changing farmers' risk taking behavior. The study also found consistent evidence that insurance that insurance had a positive and significant impact on technology adoption whereby insured farmers applied more inorganic fertilizers compared to uninsured. There was however no evidence supporting welfare gains due to insurance as expected.

According to (De Nicola, 2010) farmers fully insure against weather shocks, and the estimated welfare gains therefore correspond to the potential gains that could be seized by providing an ideal insurance product. The author finds that the provision of weather insurance boosts consumption and reduces investment, as farmers' precautionary motives to overinvest weaken considerably as insurance reduces their risk. The associated welfare gains are quite large, equivalent to a permanent increase in consumption of 16.9%,(de Nicola, 2015). Consequently, the author does conclude that indeed, weather insurance does have the potential to substantially enhance farmers' welfare.

### ***2.4.3 Impact assessment models used to analyze IBLI's effectiveness***

Haruna (2015) conducted a study on measuring the effects of weather-index insurance purchase on farm investment and yield among smallholder farmers in Northern Ghana. The objective of this study was to examine the effect of index insurance on smallholder farmers' investment decisions. The endogenous treatment-regression model and inverse-probability weighted regression analysis were used to estimate the effects of weather insurance purchase on fertilizer use intensity and on maize yield based on the assumption that selecting into treatment was based on observable and unobservable covariates respectively. The authors' findings from the endogenous treatment-regression model showed that weather index insurance purchase had a positive and significant impact on fertilizer use intensity but not on yield. Inverse-probability weighted regression analysis results showed no significance of weather index purchase on fertilizer use and yield.

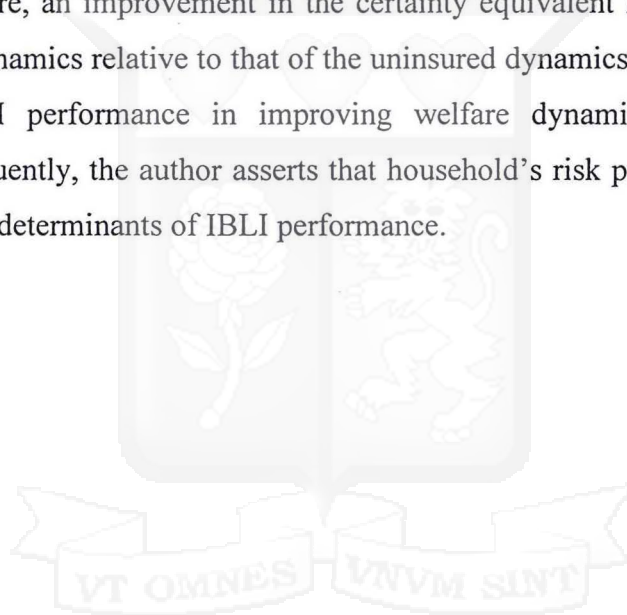
Shawn Cole et al. (2014) in an attempt to estimate the effects of rainfall insurance on real production and investment decisions by farmers employed a Randomized Control Trial (RCT) approach to elicit the causal effect of insurance coverage on behaviour. The authors found that, while insurance provision had little effect on total agricultural investments, it significantly shifted the composition of investments towards riskier production activities. In order to highlight the interaction between insurance access and production behaviour, the authors use a simple illustrative model of a farmer's entrepreneurial decisions. The key result illustrated by the model was that for a risk-averse farmer, investment in risky production activities was increasing in access to insurance against production risk. To optimize investment in the presence of insurance, the authors used the law of motion as illustrated:

End of period wealth ( $W_1$ ) = initial wealth ( $W_0$ ) + investment return ( $Y$ ) + insurance payout ( $IP$ )

$$= W_0 + \alpha (R + e) + \psi (-e + u - \mu)$$

Chantararat S. (2009) in a paper dubbed "Pro-poor Risk Management" noted that improvement in the certainty equivalent growth rate of the insured herd relative to the no-insurance case served as the evaluation criteria for IBLI. The author employed a

dynamic model with bifurcations in herd accumulation, that was highly stylized to household herd data in their northern Kenya setting. He however asserts that his model resembled other models of poverty traps\*. Livestock was used a standard unit in his model due to the fact that livestock is considered the main productive asset among pastoralists. The estimated functions that were used were estimated using the Epanechnikov kernel with the rule-of-thumb optimal bandwidth. The author defined a certainty equivalent growth rate of any stochastic herd dynamics as the constant net herd growth rate with respect to the initial herd,  $H_{it}$ , that yields the same intertemporal utility as the expected intertemporal utility obtained from the stochastic herd dynamics. Therefore, an improvement in the certainty equivalent herd growth rate of the insured herd dynamics relative to that of the uninsured dynamics, could thus represent a measure of IBLI performance in improving welfare dynamics of the insured household. Consequently, the author asserts that household's risk preference can be used as one of the key determinants of IBLI performance.



## **CHAPTER 3: METHODOLOGY**

### **3.1 Introduction**

This chapter presents the methodology for this study. The purpose of this study was to find out: (1) the impact of IBLI on risk transfer in such a way that it reduces the fear of households taking productive loans because they fear the loss of collateral; (2) the overall effectiveness of IBLI in making households more self-sufficient, relying less on food aid or assistance programs (3) an appropriate model that can be used to assess the impact of index insurance on households' welfare development and future income generation. This methodology tends to follow the structure of the study by Carter (2013) with the most significant difference being that analysis is done on an aggregate level as opposed to household specific level.

### **3.2 Research Design**

This research employs a quantitative approach to test the research hypothesis. The study will employ time series data covering the period between 2000- 2016 for the following variables: livestock sales, livestock as a contribution to GDP, Food aid (monetary and meal handouts). Data will be collected from secondary sources including FAO, ILRI and USAID data banks. An ARDL model will be employed to test the long run and short run impact of IBLI on income generation and welfare enhancement on an aggregate level after undertaking time series property tests on all the data collected.

### **3.3 Model Specification and Estimation**

The principal analysis applicable to this study is the analysis of treatment effects.

#### **3.3.1 Treatment Effect Analysis**

The topic of treatment evaluation concerns measuring the impact of interventions on outcomes of interest. The treatment evaluation approach and some of its terminology comes from medical sciences where intervention means adopting a treatment regime, (Cameron and Trivedi, 2005). The term outcome refers to changes in economic status.

The standard problem in treatment evaluation involves the inference of a causal connection between the treatment and the outcome. Such inference is the main feature of the potential outcome model (Rubin Causal Model).

According to Wooldridge (2010), most approaches to estimating treatment effects fall into one of three approaches. The first exploits ignorability of the treatment conditional on a set of observed covariates. An important benefit of the ignorability of treatment according to Wooldridge (2010), is that no functional form or distributional assumptions are needed to identify the parameters of interest. Some of the methods that fall into this category include, regression adjustment, propensity score methods and the doubly robust methods (inverse probability weighted regression adjustment and augmented inverse-probability weights).

In this study I seek to employ the inverse probability regression adjustment (IPWRA) method to estimate the impact of purchasing Index Based Livestock Insurance on pastoral households' income generation and livestock yield. IPWRA is a combination of propensity score and regression adjustment methods. It therefore only requires either the conditional mean model or the propensity score model to be correctly specified for consistent estimates.

The second approach allows selection into treatment to depend on unobserved factors, treatment is hence considered endogenous. In this case, the availability of instrumental variables (IVs) are relied on in order to identify and estimate treatment effects. Some of the methods in this category are correction function method, the control function method and the dummy endogenous variable model, Wooldridge (2010). The endogenous treatment-effects regression model is applicable to this study as it addresses the self-selection problem.

The third approach is regression discontinuity designs, where treatment or the probability of treatment is a discontinuous function of an observed forcing variable (Wooldridge, 2010). I do not wish to employ this design in this study.

### **3.3.2 Theoretical Underpinning**

The analysis of the impacts of insurance would be simplest if we could compare a cohort of households randomly assigned to an insurance "treatment" with a cohort group denied to access insurance. For this analysis we are limited only to a population in which all households had the opportunity to insure their livestock, though not all households chose

to do so. Since households must self-select into purchasing insurance, we must account for selection into the insurance treatment. A variety of techniques exist to control for selection bias. These methods vary according to the underlying assumptions that must be made to use them. Because the endogenous decision to insure is likely to depend on observables, our preferred estimates are based on instrumental variables (IV) approach.

The premier test (and control) for selection bias is to use Heckman's correction. Using this method we estimate a probit model, in which we regress the insurance decision,  $insured_i$ , (a dummy variable equal to one if the household insured any livestock) on a number of exogenous variables affecting treatment ( $Z_i$ ), including at least one variable which belongs in the selection equation but does not appear in the equation of interest. In its basic form, this first stage equation can be written:

$$Insured_i = z_i \delta + v_i \quad (1)$$

The estimated parameters are then used to calculate an inverse Mills ratio, defined as  $IMR = \frac{\phi(Z)}{\Phi(Z)}$ , which captures the part of the unexplained variation  $v_i$  that is correlated with sample selectivity. For this reason, it is informative to include the inverse Mills ratio as an additional explanatory variable in a second stage regression estimating the impact of insurance on various coping strategies.

$$action_i = \beta_0 + \beta_1 insured_i + \gamma (IMR) + \epsilon_i \quad (2)$$

If the estimated coefficient for the inverse Mills ratio is different from zero, then we should be concerned about selection bias.

### **3.4 Data types and Data Collection**

The study made use of secondary sources of data for the analysis covering the period 2000-2015.

The data on pastoral income will be obtained from the FAO(Food & Agriculture Organization of the United Nations) website databases. Data on the afore mentioned variable will be obtained from FAO databases because it includes data on this variable for the specified time period. This will greatly reduce the probability of estimation errors that come from acquiring data from many different sources. FAO can also be seen as a relatively reliable source.

Data on pastoral household welfare enhancement as a result of reduced reliance on food aid and cash handouts will be obtained from WFP(World Food Program) data bases. World Food Program data though given on month-by-month basis ,will then have to be averaged on an annual basis for this study.

The study will also make use of the Economic Surveys. Data on sectoral growth (livestock sales as a contribution to GDP) will be retrieved from this source particularly because the Economic Surveys disaggregate the data into the growth contribution by each sector in the economy.



## CHAPTER 4. DATA ANALYSIS AND PRESENTATION OF RESULTS

### 4.1 Introduction

This chapter presents the empirical findings of this study. The sections in this chapter have been divided based on the different empirical tests and models that were carried out towards achieving the research objectives of this study.

Due to limited data points, lags were restricted to between 2 and 3 depending on the regression

### 4.2 Time Series Property Results

Each of the variables in the study was tested for stationarity using the Augmented Dickey Fuller test (ADF) using the Schwarz Information Criterion (SIC) incorporating a trend.

According to the ADF test carried out, all the variables were found to be I (1) in their natural form. This implies that a regression incorporating latent variables could be used to estimate the model as all the dependent variables were (1) and all independent variables were either I (0) or I(1). The results of this analysis are shown in the table 1 below:

Table 1- ADF Test with Intercept and Trend

Variable	Level	First Difference	Order of Integration
Cattle Value	-1.636	-2.933	I (1)
Pastoralist Credit	-1.667	-6.252	I (1)
Food aid	-4.954	-3.372	I (1)
Log Cattle Value	-0.753	-5.176	I (1)
Log Pastoralist Credit	-0.477	-5.023	I (0)
Log Food Aid	-1.918	-5.913	I (1)

### 4.3 The Long Run and Short Run Dynamics- Aggregate Analysis.

Table 2 below shows the dynamics of the Rubin Causal Model using aggregate data

while Table 3,4 and 5 show the regression dynamics while incorporating a latent variable Di.

Table 2. Estimation of the Rubin Causal Model using Least Squares Method

In table 2 below, each outcome variable is regressed on a dummy whether the period is on insurance and an alternative dummy applied for period without insurance. A tobit estimator is used when the dependent variable is continuous, while a probit is used for the without insurance dummy. To conserve space, only results for the key coefficient on the insurance treatment dummy are presented.

Dependent Variable: Food Aid

Method: Least Squares

Sample :3/01/2000-12/01/2014

Included Observations: 60.

Variable	Coefficient	Std. Error	t-statistic	Probability
Constant	4.610008	1.062308	4.331266	0.0001
Livestock Credit	-0.016126	0.011141	-1.447408	0.1537
Camel Quarterly Value	501.5841	148.5254	3.377093	0.0014
Cattle Quarterly Value	-123.9164	47.10640	-2.630565	0.0111
Goats Quarterly Value	-6.468407	23.27550	-0.277906	0.7822
Sheep Quarterly Value	-29.47994	45.85975	-0.642828	0.5231
Dummy	47729529	24748770	1.928562	0.0591
R-squared	0.305182	Mean dependent var		909983
Adjusted R-squared	0.226523	S.D. dependent var		394582
S.E. of regression	34702546	Akaike info. Criterion		37.671
Log likelihood	6.38E+16	Schwarz criterion		37.916
F-Statistic	-1123.154	Hannan Quinn crit.		37.767

Prob(F-statistic)	0.002775	Durbin- W
atson stat		0.405974

According to the results in table 1 above, Index Based Livestock Insurance is found to have a statistically insignificant effect of the insurance treatment on food aid sought after insurance intervention. However when simulations on consecutive years were conducted, the treatment effect becomes larger, and are also statistically significant at the 5% level or lower in each specification. Quantitatively, assignment to the insurance treatment group increases the probability of not relying on food aid by 6 percentage points (or 12 percent). This is informed by the 5.9% significance level while all other independent variables are insignificant. The error correction term in the model was negative and significant which indicates that there is a steady long run relationship between food aid and Index Based Livestock Insurance.

**Table 3:Regression analysis:Food Aid.**

Residual standard error: 169500 on 13 degrees of freedom.

Multiple R-squared: 0.07287, Adjusted R-squared: 0.001553

F-statistic: 1.022 on 1 and 13 DF, P- value 0.3305

Coefficient	Estimate	Standard Error	t-value	Pr. (> t )
(Intercept)	401153	53606	7.483	-4.61e-06
X1	-93854	92849	-1.011	0.331

Similar to the findings obtained from the method of least squares estimation the study finds no statistically significant effect of assignment to the treatment group on reliance on food aid. The P-value in the regression analysis is 0.3305 which consequently suggests the insignificant impact of index insurance on reliance on food aid. The reason for this finding could be that it takes time for the impact of insurance geared towards livestock indemnity to be realized in the welfare enhancement of the insured people.

**Table 4: Regression analysis: Credit Volumes to Pastoralists**

Residual standard error: 2987 on 13 degrees of freedom.

Multiple R-squared: 0.746, Adjusted R-squared: 0.7264

F-statistic: 38.17 on 1 and 13 DF, P- value 3.331e-05

<b>Coefficient</b>	<b>Estimate</b>	<b>Standard Error</b>	<b>t-value</b>	<b>Pr. (&gt; t )</b>
(Intercept)	5786.1	944.5	6.126	3.63e-05
X1	10107.9	1636.0	6.179	3.33e-05

Contrary to the findings on the reliance on food aid, the study finds a significant relationship between Index Linked Insurance and credit volumes advanced to pastoralists. The R-squared figure 0.746 , implies that following the introduction of index based livestock insurance, credit volumes advanced to pastoralists had a 74% increase. This could possibly mean that lenders were more willing to advance credit to pastoralists and that pastoralists were more confident to seek credit in response to the insurance backing. While the study does not find any evidence that the treatment affected total indebtedness, the study finds that it affected positively the credit seeking behaviour of pastoralists towards expensive debt, defined as debt from money lenders, microfinance institutions (MFIs) and other sources. These three sources charge an average interest rate

of 31%, compared to debt from family, typically given at zero interest rate, or debt from commercial banks.

These results can also be interpreted to mean that insurance recipients that did not receive a payout needed to resort to expensive sources of credit to invest or to sooth consumption , because of the higher risks taken. But treated pastoralists in areas where the insurance policy did pay out were able to use their payouts to reduce their reliance on expensive forms of indebttness.

**Table 5: Regression analysis: Livestock Value**

Residual standard error: 649.2 on 13 degrees of freedom.

Multiple R-squared: 0.5551, Adjusted R-squared: 0.5209

F-statistic: 16.22 on 1 and 13 DF, P- value 0.001437

<b>Coefficient</b>	<b>Estimate</b>	<b>Standard Error</b>	<b>t-value</b>	<b>Pr. (&gt; t )</b>
(Intercept)	1718.3	205.3	8.371	1.36e-06
X1	1431.9	355.6	4.027	0.001437

Following the regression, the study finds that Index Based Livestock Insurance is significant in boosting livestock value from the insured pastoralists. The model suggests that following the introduction of livestock insurance, livestock value increased by 52% as evidenced by the R-squared figure. The statistic suggests that the effect of the insurance treatment is quite non-linear. Insurance causes a sizeable number of farmers to switch on the extensive margin from not keeping higher breed beef cattle into rearing higher breed cattle, consistent with the probit regression estimates. But for pastoralists with no access to credit to facilitate purchase of the higher breed cattle, insurance provision has little or no effect on the value derived from their livestock . In other words, the effect of insurance is primarily on the extensive rather than the intensive

margin.

The increase in livestock value could be explained by the move of pastoralists to pursue more entrepreneurial ventures by investing in better breed of livestock which prior to insurance were considered high risk investments. Around this decision threshold, the provision of insurance against income risk makes pastoralists more willing to invest in higher breed cattle.



## **CHAPTER 5. CONCLUSION AND RECOMMENDATIONS**

### **5.1 Summary**

The purpose of this study was to examine the effect of Index Based Livestock Insurance on Pastoralists' welfare, economic advancement and credit seeking behaviour.

To address the above objectives, time series data was collected for the period 2000 to 2015. The Rubin Causal Model was used to specify the short run and long run dynamics of the endogeneous treatment regression model and the inverse probability weighted regression adjustment model.

The study factored in the macroeconomic policy environment data, which was composed of aggregate data of pastoralists' livestock value, credit volumes and food aid. This was done in line with the findings on the importance of a good macroeconomic environment for insurance intervention effectiveness.

Overall, the study found that Index Based Livestock Insurance had a positive effect on the economic enhancement of the insured pastoralists. Specifically the insurance intervention was found to have a positive impact on the value that the pastoralists derived from their animals and on their credit seeking behaviour.

Index Based Livestock Insurance was found to have an insignificant impact on pastoralists' reliance on food aid. This finding could be attributed to the assumption that it takes time for the impact of insurance geared towards livestock indemnity to be realized in the welfare enhancement of the insured people

### **5.2 Conclusion**

In conclusion, the study finds that Index Based Livestock Insurance positively affects livestock value and credit seeking behaviour of pastoralists in Kenya. Its effect on reliance on food aid was however found to be insignificant. Insurance intervention was found to be effective in influencing economic enhancement which can intuitively be interpreted to mean that the pastoralists pursue more entrepreneurial ventures when backed with insurance.

Consequently, the provision of insurance against an important source of risk influences production decisions by pastoralists. In particular, it causes substitution in agricultural

investments towards higher breed livestock .

### **5.3 Policy Implications**

The study's findings, as well as results from other recent research, suggest that insurance arrangements that "fill in" missing markets have significant effects on entrepreneurial production and risk-taking, consistent with models from producer theory and corporate finance. Consequently, financial innovations that improve risk diversification, such as the insurance policy studied here, may play a significant role in boosting growth and real incomes in emerging market economies.

### **5.4 Shortcomings and Areas of Further Research**

One shortcoming of this study was the limited data points especially for the credit volumes advanced to pastoralists. Only five years of post insurance data was collected and therefore the data had to be converted into quarterly data using the quadratic approach to get more data points. As a result, the aggregate analysis of pastoralists' credit seeking behaviour may not be fully reliable. Additionally, important sectors such as live animals traded were excluded from the analysis because of incomplete data points.

Another shortcoming of this study could be the fact that the lags could have eaten up degrees of freedom thereby reducing the statistical power of the models run.

A potential area for further research could be to carry out a research to understand the extent and implications for welfare of basis risk, and to improve on product design and data infrastructure in order to improve the connection between insurance payouts and shocks to pastoralists.

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**APPENDICES.**

*Appendix 1: Results on Stationarity Tests.*

Table 6- 8: Stationarity tests on all predictor variables.

Correlogram of GOATS\_QUARTELY\_VALUE

Date: 11/14/17 Time: 11:14  
 Sample: 3/01/2000 12/01/2014  
 Included observations: 60

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.929	0.929	54.437	0.000	
2	0.858	-0.037	101.69	0.000	
3	0.788	-0.038	142.17	0.000	
4	0.717	-0.040	176.30	0.000	
5	0.668	0.120	206.46	0.000	
6	0.619	-0.031	232.85	0.000	
7	0.570	-0.032	255.65	0.000	
8	0.521	-0.033	275.08	0.000	
9	0.485	0.087	292.23	0.000	
10	0.449	-0.028	307.21	0.000	
11	0.413	-0.029	320.13	0.000	
12	0.376	-0.030	331.12	0.000	
13	0.318	-0.162	339.13	0.000	
14	0.260	-0.041	344.60	0.000	
15	0.202	-0.043	347.96	0.000	
16	0.143	-0.045	349.70	0.000	
17	0.087	-0.072	350.35	0.000	
18	0.030	-0.052	350.44	0.000	
19	-0.026	-0.054	350.50	0.000	
20	-0.083	-0.058	351.13	0.000	
21	-0.106	0.173	352.19	0.000	
22	-0.128	-0.041	353.81	0.000	
23	-0.151	-0.042	356.12	0.000	
24	-0.174	-0.044	359.26	0.000	
25	-0.232	-0.228	365.00	0.000	
26	-0.290	-0.070	374.21	0.000	
27	-0.348	-0.076	387.87	0.000	
28	-0.406	-0.082	407.03	0.000	



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 Correlogram of CATTLE\_QUARTELY\_VALUE

Date: 11/14/17 Time: 11:00  
 Sample: 3/01/2000 12/01/2014  
 Included observations: 60

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.950	0.950	56.649	0.000	
2	0.889	-0.026	108.70	0.000	
3	0.849	-0.027	155.70	0.000	
4	0.788	-0.027	198.02	0.000	
5	0.746	-0.051	235.61	0.000	
6	0.693	-0.030	268.68	0.000	
7	0.640	-0.031	297.44	0.000	
8	0.587	-0.032	322.13	0.000	
9	0.544	0.083	343.72	0.000	
10	0.501	-0.028	362.37	0.000	
11	0.457	-0.029	378.24	0.000	
12	0.414	-0.030	391.52	0.000	
13	0.372	-0.015	402.50	0.000	
14	0.331	-0.031	411.35	0.000	
15	0.290	-0.032	418.30	0.000	
16	0.248	-0.033	423.51	0.000	
17	0.200	-0.094	428.97	0.000	
18	0.152	-0.040	429.02	0.000	
19	0.104	-0.042	430.01	0.000	
20	0.055	-0.043	430.30	0.000	
21	-0.003	-0.152	430.30	0.000	
22	-0.061	-0.059	430.57	0.000	
23	-0.120	-0.053	432.12	0.000	
24	-0.179	-0.057	435.44	0.000	

Date: 11/14/17 Time: 11:15  
 Sample: 3/01/2000 12/01/2014  
 Included observations: 60

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.939	0.939	55.555	0.000
		2	0.877	-0.032	104.93	0.000
		3	0.816	-0.033	148.39	0.000
		4	0.755	-0.034	186.22	0.000
		5	0.709	0.093	220.18	0.000
		6	0.662	-0.028	250.39	0.000
		7	0.616	-0.029	277.03	0.000
		8	0.570	-0.030	300.26	0.000
		9	0.539	0.115	321.44	0.000
		10	0.508	-0.024	340.63	0.000
		11	0.477	-0.024	357.90	0.000
		12	0.446	-0.025	373.30	0.000
		13	0.381	-0.281	384.79	0.000
		14	0.316	-0.044	392.87	0.000
		15	0.251	-0.046	398.09	0.000
		16	0.186	-0.048	401.03	0.000
		17	0.143	0.098	402.81	0.000
		18	0.100	-0.040	403.69	0.000
		19	0.056	-0.041	403.97	0.000
		20	0.013	-0.043	403.99	0.000
		21	-0.029	-0.073	404.07	0.000
		22	-0.071	-0.050	404.57	0.000
		23	-0.114	-0.053	405.87	0.000
		24	-0.156	-0.056	408.38	0.000
		25	-0.214	-0.095	413.27	0.000
		26	-0.273	-0.067	421.42	0.000
		27	-0.331	-0.072	433.80	0.000
		28	-0.390	-0.078	451.49	0.000

### Appendix 2: Selected Variable Definitions

VARIABLE	DEFINITION, MEASUREMENT & A PRIORI EXPECTATIONS
Liquid Savings	Amount of savings at the bank, Post Office and cash at home.
Livestock	Buffalos, cows, young calves/young stock, oxen/bullocks, goats and sheep.
Total Daily Consumption	Total daily consumption, measured by summing consumption of different items measured over different time intervals between one day and three months

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(normalized to a per-day basis in each case).

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Wealth index: PCA

First component of a principal component analysis (PCA). Variables includes a dummy if the pastoralist owns a specific type of livestock, the log of the total value of livestock, a dummy if pastoralists has any type of savings, the log of total amount of savings and credit.

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