Measuring the Effects of Weather-index Insurance Purchase on Farm Investment and Yield among Smallholder Farmers in Northern Ghana

THESIS

Presented in Partial Fulfillment of the Requirements for the Degree Master of Science in the Graduate School of The Ohio State University

By

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2015

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Abstract

This study sought to investigate the effects of weather-index insurance purchase on farm investment among smallholder farmers in northern Ghana. Data was collected from a survey of 80 purchasers and 150 non-purchasers of weather-index insurance. 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 assumptions that selectin into treatment is based on unobservable and observable covariates respectively. A logistic regression model was also run to examine the factors that influence weather-index insurance purchase.

Results of the logistic regression revealed membership of an organization, total number of land owned, number of acres cultivated yearly, number of livestock owned, size of household, number of adults in a household and awareness of weather-index insurance to be the factors that determine weather-index insurance purchase among smallholder farmers in northern Ghana.

Results from the endogenous treatment-regression model showed weather-index insurance purchase has a positive and significant impact on fertilizer use intensity but not on yield. IPWRA results showed no significance of weather-index insurance purchase on fertilizer use and on yield.

Dedication

I dedicate this work to my wife Rukaya Shani and my son Ridhwan Saha

Acknowledgement

Above all, I give thanks and praise to the Almighty Allah for everything in my life.

I express my profound gratitude to my advisor, Professor Brent Sohngen for his invaluable support academically and financially to ensure this work is done successfully. I again in general express my heartfelt gratitude to all the professors who have taught me in the Agricultural, Environmental and Development Economics Department of The Ohio State University. It is the knowledge you have imparted on me that has enabled me carry out this work successfully.

I am particularly grateful to Patricia Rigby of the International Programs Office in Agriculture for the immense support she provided me throughout the duration of my studies. Pat always made sure I never lacked anything and always ensured I was living comfortably. No amount of words to express my gratitude to you, Pat but to say thank you. I also thank Susan Miller for her excellent administrative work.

I acknowledge the Borlaug Higher Education on Agricultural Research and Development (BHEARD) for giving me a full scholarship to study in the US and also providing part of the funding for this thesis.

Last but not least, I give thanks to the director of CSIR-SARI, Dr. S. K Nutstugah for the continuous support he has shown me all these years.

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Fields of Study

Major Field: Agricultural, Environmental and Development Economics

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CHAPTER ONE

1.1 Introduction

Agriculture is the mainstay of the Ghanaian economy, employing about 42% (GSS, 2010) of the labour force as in formal and informal employment as well as contributing an average of about 22 percent to the country's Gross Domestic Product (GDP) in 2012 (GSS, 2014). It is also the largest foreign exchange earner (about 60%) (MoFA, 2010a; GoG, 2009; ISSER, 2010). Smallholder producers form about 90 percent of the farming population in Ghana (Assuming-Brempong *et al.*, 2004). Available statistics indicate that the average farm size is about 3.9 hectares and over 50 percent of households own less than 3 hectares of land. Nyanteng and Seini (2000) observed that more than 90 percent of Ghana's food production is derived from holdings of 3 hectares (ha) or less. Chamberlin (2007) also found that more than 70 percent of Ghanaian farms are 3 hectares (ha) or smaller in size.

Crop production in Ghana is predominantly rain-fed with outputs largely dependent on the amount and distribution of rainfall (Seini, 2002). As a result, crop output in Ghana is highly correlated with the rainfall pattern. This heavy dependence on an increasingly unpredictable rainfall pattern and amounts makes crop production in Ghana a very risky enterprise. The situation is further worsened by the fast changing climate. Morton (2004) notes that some of the most important impacts of climate change will be felt by the category of people, mostly referred to as smallholder farmers in developing countries. Ghanaian smallholder farmers fall into this category. Kwadzo et al. (2013) indicates that poor households in Ghana who mostly depend on small-scale, rain-fed agriculture for their livelihood, face substantial yield and income risks arising out of their individual idiosyncrasies and also risks that are inextricably linked with the production environment. Farmers in Northern Ghana are the most exposed to the effects of climate change in terms of increased frequency of drought and occasional flooding (Etwire, 2013). For poor farmers, a variable and unpredictable climate presents a risk that has the potential to critically limit options and restrict development. The risk manifests in two different forms; the direct effects of a weather shock and the indirect effects due to the threats of a weather shock (Hellmuth et.al, 2009).

When a weather shock occurs, farmers cope after the fact. If the shock is large enough, poor farmers may be forced to sell their few assets to survive, and when the crisis is over, they typically are in much worse position than before (Hellmuth et.al, 2009). Households may attempt to cope by engaging in informal sharing networks and informal credit arrangements (Carter et al., 2007, Morduch, 1999), but it is not clear how these coping strategies affect production decisions and welfare.

Under the threat of a possible weather shock, households may make an *a priori* decisions to reduce the impacts of the shock. In some cases, poor farmers avoid taking risks (Rosenzweig and Wolpin, 1993) and they shun innovations that could increase productivity, since these innovations could increase their vulnerability, for example by exhausting the assets they would need to survive a crisis (Hellmuth et.al, 2009). These ex-ante risk management decisions or strategies have implications for production decisions as well as welfare of households (Carter and Barrett, 2006; Rosenweig and Binswanger, 1993).

Gine et al (2007), observe that weather shocks are spatially covariant, affecting all households nearby thereby drastically limiting the effectiveness of informal risk sharing networks. Distressed sales of livestock flood the market, causing livestock prices to decline.

The management of inherent risks associated with agricultural crop production remains the key challenge in the development and poverty reduction program of Ghana since independence (Kwadzo et al. 2013).

Formal insurance presents a strategy to pool and transfer risk (Awel and Azomahou, 2014), and potentially benefit farmers, especially small-holders. Kwadzo et al (2013) suggest that market-based crop insurance is the most effective management strategy that farmers can use in today's agriculture where the degree of uncertainty is highly associated with high loss. Hess (2003) also suggests that crop insurance can serve as an important ex-ante risk management strategy for rural farmers in developing economies to cope with production risk resulting from variations in weather conditions (climate change). Provision of insurance could take away both the ex-ante and ex-post risks from farmers, thereby allowing them to invest more and cushioning them through insurance payouts respectively. However, as noted by Hellmuth et al (2009), this formal crop insurance is generally not available in developing countries, where insurance markets are limited if they exist at all, and are not oriented towards the poor. A new type of insurance, weather-index insurance, has been identified as the solution to manage poor farmers' risks especially in developing countries.

Index insurance is a contract that pays for losses based on an index, an independent and objective measure that is highly correlated with losses such as extreme weather. Index insurance contracts, such as rainfall insurance, circumvent the moral hazard and adverse selection problems that plague traditional insurance (Skees 2008). Moral hazard is suppressed since farmers' indemnification is independent of their individual losses. On the other hand, adverse selection is suppressed because every farmer faces the same insured risks. Weather index insurance is one of a number of index-based financial transfer products that have the potential to help protect people and livelihoods against climate shocks and climate risk (Hellmuth et al, 2007).

In recent years, there has been excitement among academia as well as practitioners about the prospects of introducing weather index insurance to manage smallholder farmers' risks in developing countries (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; Cole & Vickery, 2014)

In Ghana, weather-index insurance was introduced by the Ghana Agricultural Insurance Pool (GAIP) in 2011, as a means to reduce the financial risk of crop failure and to also encourage farmers to invest more on their farms in order to increase production. The weather insurance product is targeted at only smallholder farmers with farm sizes less than 20 ha. At its introduction in 2011, it covered 3000 farmers in the three northern regions and was scaled up to six regions during the 2012 cropping season.

1.2 Problem Statement

The risk of food insecurity due to climate change in developing countries has encouraged development partners to seek new approaches to improve resilience of subsistence agriculture to covariate shocks. Such innovative approaches include investment in safety nets such as rainfall or index insurance (Muamba and Ulimwengu, 2010). Proponents of weather index insurance argue that it is a strategy to reduce risk, improve productivity, and increase welfare among poor farmers 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 alternative method for increasing uptake of agricultural technology.

The weather-index insurance being implemented in Ghana was also introduced with similar objectives; to reduce risk of crop failure and to encourage farm investment. Several other countries have implemented weather index insurance with similar objectives. Nevertheless, the impact of weather index insurance is still widely unknown (Hellmuth et al, 2009). It is therefore necessary to find answers to the following research questions:

i) Do smallholder farmers adopt index insurance products where available?

ii) What factors determine the purchase of index insurance?

iii) How does weather index insurance purchase affect smallholder farmers' investment decision?

1.3 Research Objectives

The main objective of this study is to examine the effect of index insurance on smallholder farmers' investment decisions. Specifically, the study aims to:

i) Determine factors that affect weather index insurance purchase.

ii) Examine the effect of weather-index insurance on intensity of fertilizer use.

iii) Examine the effect of weather index insurance on yield.

1.4 Justification of Research

The government of Ghana has been implementing policies that aim to increase farm level investment (particularly input use) especially among smallholder farmers in order to boost crop production. Notably is the fertilizer subsidy program that aims at making fertilizer accessible and affordable to smallholder farmers. Findings from this research could help shape the efforts of government and its development partners to a more effective way of helping farmers increase their production through farm investment.

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 has been put to promote it. Despite the many resources devoted to promote weather index insurance, there has been little research to quantify its benefits (Morduch, 2006). As observed by Morduch (2006), "The expanding gaggle of micro insurance advocates are ahead of the available evidence on insurance impacts". This research could provide empirical evidence for the continuing support or otherwise of weather index insurance.

The literature on weather index insurance has mainly been centered on the demand and feasibility of index insurance products. According to Cole et al (2012), even though there are a few high-quality overviews of index insurance, many of the studies contain overviews of the concept behind index insurance, case studies and history of existing programs but contain few results on the determinants of take-up or the impact of insurance. Again Cole et al (2012) on a systematic review of the effectiveness of index-based micro-insurance in helping smallholders manage weather-related risks conclude that very few real-world empirical evaluations of index-based micro-insurance programs exist and therefore recommended that research on how access to insurance affects agricultural investment choices needs to be extended. This study therefore intends to provide empirical evidence of the impacts of weather index insurance among smallholder farmers.

1.5 Organization of Study

This report is organized into five chapters. A review of existing body of knowledge on weather index insurance impact on technology adoption and household welfare, farmers' informal risk coping mechanisms, smallholder farmers adaptation strategies to climate change, a review of the methods of analysis employed in the study are presented in Chapter two.

Chapter three focuses on the methodology of the study. It discusses the empirical models employed by the study and also describes survey techniques and sources of data used in the study.

The results and discussions of the study are presented in Chapter four, with Chapter five containing the summary and conclusions and recommendations emanating from the study.

CHAPTER TWO

2.0 Literature Review

In this chapter, I take a look at previous studies on weather index insurance, farmers risk coping strategies, farmers' adaptation strategies to climate change, etc.

2.1 Impact of Weather Index Insurance on Technology Take-Up, Investment and Welfare

There are recent studies that examined the impact of weather index insurance on new agricultural technology adoption. A comprehensive review of weather index insurance has been done by Cole et al (2012).

deNicola (2011), through numerical simulations show that the provision of weather index insurance increase the take up of high-risk high-productivity technology among Malawian farmers. Karlan et al (2013) in a randomized control trial also find that weather index insurance leads to riskier production choices in agriculture among smallholder farmers in northern Ghana. In a related study on how risk management influences production decisions, Cole et. al (2014) demonstrate through randomized control trial that insured farmers are more likely to devote larger amount of inputs to high risk but profitable castor and groundnut crops in India. Carriquiry and Osgood (2012) investigate the relationship between input choice and index insurance under uncertainty and find that levels of input usage increase when farmers are insured. Hill and Visceisza (2010) find a positive effect of insurance provision on technology adoption (fertilizer purchase) among Ethiopian farmers in a framed field experiment. Mobarak and Rosenzweig (2012) find that insured farmers in India take less ex-ante risk mitigating measures against weather shocks. They reported insured farmers going in for high yielding rice varieties.

Cai (2012) in an impact study of insurance provision on households' production and financial decisions among tobacco farmers in China, find that introducing insurance increases the production area of the insured crop by almost 20% and decreases production diversification. She also finds that insured farmers' credit demand increase by 25%. 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.

In terms of investment decisions, Karlan et al. (2013) conducted a field experimental study of agricultural decisions after relaxing risk and credit constraints in northern Ghana. They find index insurance to significantly lead to larger agricultural investment. In particular, they find that the binding constraint to farmer investment is uninsured risk, and that when provided with insurance against a catastrophic risk they face, farmers are able to find resources to increase expenditure on their farms. In an evaluation of the impact of large commercially traded index-insurance on technology adoption, productivity and welfare, Awel and Azomahou (2014) find that insurance enhances the adoption of technology (fertilizer purchase) and also increases farm productivity among Ethiopian farmers. In contrast, Farrin and Murray (2014) find that index insurance, by reducing the disposal wealth of households in years where no payouts occur, can dampen demand for fertilizer at the farm level.

The impact of weather insurance on welfare has been ambiguous so far in the literature. For instance Awel and Azomahou (2014) find that there is no evidence of welfare improvement as a result of weather insurance provision among farmers in Ethiopia. In contrast de Nicola (2011) in a dynamic stochastic model finds that weather insurance has the potential to provide substantial welfare gains equivalent to almost a 17% permanent increase consumption. Similarly, Janzen and Carter (2013) examined the impact of microinsurance on consumption smoothing and asset protection in Kenya. They find that insured households are 36 percentage points less likely to anticipate drawing down assets, and 25 percentage points less likely to anticipate reducing meals upon receipt of insurance payout. They suggest that insurance can help households to protect assets during crisis, without having the deleterious effect on human capital investments.

2.2 Farmers' Informal Risk Coping Mechanisms

Risk is intrinsically linked to agriculture, especially in developing countries. Farmers have developed strategies to mitigate this inherent risk in agriculture.

In the absence of formal insurance, there are ways farmers engage in ex ante risk management, albeit all those ways involve tradeoffs. One strategy is to allocate productive resources toward less risky activities. Morduch (1999) states that households choose to forgo valuable technologies and profitable opportunities. For instance, Morduch (1995) observes that poor households tend to devote a larger portion of crop land to less risky traditional varieties. Kassie et al. (2009) also find evidence of limited modern input use because of the presence of production risk. However, these lower risk activities generally yield lower return (Janzen and Carter, 2013).

Farmers also choose to reduce their risk exposure through diversification of crop choice, assets or activities, however such diversification is not always possible, and can only be beneficial if the risk involved is not perfectly correlated across the various activities (Dercon et al. 2008).

Livestock holdings are another way by which farmers manage risk. However, as Fafchamps et al. (1998) point out, such asset holdings are a very poor hedge against widespread weather shocks, since during such events, many farmers simultaneously attempt to sell off their assets, leading to lowering of prices. Similarly, Kazianga and

Udry (2006) find evidence that grain stocks serve as self-insurance in rural Burkina Faso.

Another risk coping mechanism farmers use is to work off-farm. That is, engaging in nonfarm labour. For instance, Kochar (1999) finds that farm households in India shift from working on the farm to becoming formally employed outside of the home.

2.3 Farmers Adaptation Strategy to Climate Change

Adaptation strategies in the context of climate change are all practices that smallholder farmers use to either get used to, or reduce the adverse effects of climate change. Etwire (2013) classifies smallholder farmers' climate change adaptation strategies into two; indigenous adaptation strategies and introduced adaptation strategies.

Indigenous adaptation strategies are all those technologies and practices that have or are perceived to have originated from the farmers themselves, be it a novelty by the current generation or a hand over by previous generations whereas introduced adaptation strategies are those technologies used by smallholder farmer that were either developed or promoted by formal research or experimental stations (Etwire, 2013).

Several authors have identified many indigenous strategies that are used by smallholder farmers in particular to adapt to the adverse effects of climate change. Planting of several crops to avoid total crop failure due to climate change has been identified as an indigenous adaptation strategy by Hassan and Nhemachena (2008), Gbetibouo (2009) and Doressa et al (2010). Molua and Lambi (2006) also observe that smallholder farmers cultivate short seasonal local varieties as an adaptation strategy to climate change. Changing the timing of farm operations is also a common indigenous strategy by which resource poor smallholder farmers adapt to climate change (Boko et al., 2007, Easterling et al., 2007, FAO, 2009b). Doressa et al. (2010) again identify crop and livestock integration as well as livestock diversification as mechanisms through which farmers adapt to climate change.

There are quite a number of introduced adaptation strategies to climate change and variability in the literature. For instance, Hassan and Nhemachena (2008) observe there have been crop varieties that are tolerant to unfavorable climatic conditions (drought, flood, etc) introduced to smallholder farmers to help them adapt to climate change. Modernization of irrigation system is also an introduced strategy that helps smallholder farmers adapt to the changing climate (Gbetibouo, 2009, FAO, 2009b, Hassan and Nhemachena, 2008). According to Altieri and Koohafkan (2008), farmers also adapt to climate change through the use of agroforestry systems. Other introduced adaptation strategies identified in the literature are the use of improved meteorological forecast, good agricultural practices, integrated pest and disease management (Easterling et al., 2007), integrated soil fertility management (Molua and Lambi, 2006, Easterling et al., 2007, Hassan and Nhemachena, 2008, FAO, 2009b) and farm insurance (FAO, 2009b).

2.4 Review of Methods of Analysis

Two principal analysis are applicable to this study, namely, analyzing treatment effects and qualitative response regression analysis of weather index insurance purchase.

2.4.1 Treatment Effects 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 frequently means adopting a treatment regime (Cameron and Trivedi, 2005). The term outcome refers to changes in economic status or environment on economic outcomes of individuals.

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) that is discussed in chapter three of this study.

According to Wooldridge (2010), most approaches to estimating treatment effects fall into one of three approaches. The first exploits ignorability or unconfoundedness 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 population 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). For more detailed discussion of these methods please refer to Wooldridge (2010).

However in this study, I used the inverse probability regression adjustment (IPWRA) method to estimate the impact of purchasing weather-index insurance on fertilizer use intensity and maize 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. In other words the treatment is 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 (herein referred to as endogenous treatment-effect regression model) Wooldridge (2010). Details of these methods are found in Wooldridge (2010) and Cameron and Trivedi (2005). I used the version of the endogenous treatment-effects regression model developed by Heckman (1978) and Maddala (1983) in this study because 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). Again Wooldridge (2010) provides detailed treatment of this approach. I did not use this design in this study.

2.4.2 Qualitative Response Regression Analysis

In modeling the factors that influence the decision to purchase weather index insurance, the study employs qualitative response regression models since the dependent variable is measured qualitatively.

According to Gujarati (2004), qualitative response regression models also sometimes referred to as probability models, are a class of models in which the dependent variable is qualitative in nature; it assumes values of only a limited range of whole numbers. If the dependent variable assumes only two values, for example, a farmer either buys or does not buy weather index insurance, it is known as a binary or dichotomous variable. If the outcomes are more than two then it is a polychotomous variable. This study employs the binary response model because the dependent variable takes on only two values.

There are three approaches to developing a probability model for a binary response variable; the linear probability model, the logit model and the probit model (Gujarati, 2004, Wooldridge, 2010).

The linear probability model is a typical linear regression model with the dependent variable being binary. Its advantages are that it is comparatively simple and can be estimated by Ordinary Least Squares (OLS). Despite these advantages, the linear probability model has got several drawbacks. Notable among them are non-normality of the error term, heterokedastic variances of the errors, and most seriously, the conditional probabilities are not guaranteed to lie between zero and one.

The logit model overcomes the problems of the linear probability model. The logit model uses the logistic cumulative density function to model the binary response variable. As a result the conditional probabilities generated from the logit model lie between zero and one. The probit model is very similar to the logit model, with the only difference being that the normal cumulative density function is used to model the binary response variable. As such the probit model also overcomes all the disadvantages of the linear probability model discussed above.

In this study, I use the logit model to estimate the factors that influence weather index insurance purchase. The choice of the logit over the probit is purely based on personal preference because they both produce similar results.

CHAPTER THREE

3.0 Introduction

In this chapter, I present a theoretical framework for the study. I also present the logit model used to investigate factors influencing weather index insurance purchase. The sampling procedures implemented in the study are also discussed in this chapter. Finally, variables included in the regression analysis are explained alongside their a priori expectations.

3.1 Theoretical Framework

The focus of this study is to measure the impact of weather insurance on smallholder farmers who purchased insurance compared to those who did not purchase during a particular observational period. Hence I intend to make a causal inference. According to Wooldridge (2010), the organizing principle of modern approach to program evaluation is the counterfactual framework pioneered by Rubin (1974).

The Rubin Causal Model (RCM)/ 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.

$$potential\ outcome = \begin{cases} Y_{1i} if\ Di = 1 \\ Y_{0i} if\ \ Di\ = 0 \end{cases}$$

The observed outcome Y_i, can be written in terms of the potential outcome as follows;

$$Y_i = \begin{cases} Y_{1i}\ \ if\ Di = 1 \\ Y_{0i}\ if\ \ Di\ = 0 \end{cases}$$

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

In this form, $Y_{1i} - Y_{0i}$ is the causal effect of the treatment for an individual. But in practice or in reality, 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:

$$E[Y_i|D_i = 1] - E[Y_i|D_i = 0]$$

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

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 averages 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 measuring. 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 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. Angrist and Pischke (2008) observe that, the goal of most empirical economic research is to overcome selection bias, and therefore to find the true causal effect of the treatment variable.

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. Unfortunately, in most empirical economic research, and in our case in particular, there's no randomization. Farmers choose to purchase weather insurance.

Several methods have been proposed to address the selection bias in empirical research where randomization is often not done. These methods are often based on whether the factors that account for self-selection into treatment groups are observable or unobservable. In this study, I will employ methods based on both assumptions.

3.1.1 Endogenous Treatment Regression Model

The endogenous treatment-regression model also called endogenous binary-variable model or endogenous dummy-variable model (Heckman, 1978) is a linear potential-outcome model that allows for a specific correlation structure between the unobservables that affect the treatment and the unobservables that affect the potential outcomes (Stata 13 Documentation). Cameron and Trivedi (2005) describe this model as belonging to a class of models called Roy models. 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 binary-variable model as an 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,

$$y_{1i} = x'\beta_i + \mu_{1i},$$

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

$$D_i^* = z'\gamma + \epsilon_i,$$

where, D_i is a latent variable such that

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

The underlying assumption is that $E[\mu_1|x, z] = E[\mu_0|x, z] = 0$. It is also assumed that the triple errors $(\mu_{1i}, \mu_{0i}, \epsilon_i)$ are jointly multivariate normal distributed with zero mean and covariance matrix given by $\sum = \begin{bmatrix} \sigma_{11} & \sigma_{10} & \sigma_{1\epsilon} \\ \sigma_{10} & \sigma_{00} & \sigma_{0\epsilon} \\ \sigma_{1\epsilon} & \sigma_{0\epsilon} & \sigma_1 \end{bmatrix}$

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

$$y_{1i} - E[y_{0i}|D_i^* = 1] = y_{1i} - x'\beta_0 + \sigma_{0\epsilon}\frac{\phi(z'\gamma)}{\left(1 - \Phi(z_i'\gamma)\right)},$$

which may also be written as

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

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

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

3.1.2 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 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. This means that, conditional on the 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;

$$\min_{\alpha 1,\beta 1} \sum_{i=1}^{N} (y_i - \alpha_1 - \beta_1 x_i)/p(x_i, \hat{\gamma}) \quad if\ I_i = 1$$

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

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

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

3.2 Modelling Weather Insurance Purchase

The logit model was employed to model the purchase of weather index insurance. Green (2002), states the logit model as;

$$Prob(Y = 1|x) = \frac{e^{x'\beta}}{1 + e^{x'\beta}}.$$

The probit model could also have been used to model insurance purchase and would have produced similar results but the logit model was chosen because of its simplicity and easy interpretability.

3.3 Sampling Technique and Data

3.3.1 Sampling Procedures

A total of 230 respondents were sampled during the survey. The sample comprised 80 farmers who bought weather insurance and 150 who farmers who did not buy the insurance product. A list of communities in which weather index insurance was introduced, as well as a list of farmers who bought weather-index insurance in those communities was obtained from the Agricultural Development and Value Chain

Enhancement (ADVANCE) office. Two stage sampling procedure was used. In the first stage, a random sample was made to select 10 of the communities in which weather index insurance was introduced. In the second stage, 15 households that did not buy weather index insurance were randomly selected from each community to make up 150, then 8 households who bought weather index insurance were also randomly selected to make up 80.

3.3.2 Data, Variables and Priori Expectations

The data for the study was collected through informal interviews of the sampled farmers with semi-structured questionnaires. The questionnaire was designed to generate information that describes the demographic characteristics of the sampled households, their production characteristics and wealth indicators.

Insurance status was a dummy variable and was assigned the value of 1 if the respondent bought weather index insurance and 0 if respondent had not bought weather index insurance in the 2014-2015 crop season. Wealth indicator was measured by the number of livestock (cattle, goat and sheep) owned by households. Educational status of respondents was measured by the number of years spent in formal educational institution. Table 1 presents the variables included in the model of weather insurance purchase and their a priori expectations.

Table 1: Variables Used in the Regression Analysis

Variable	**Definition**	**Measurement**	**Priori Expectation**
Ageresp	Age of respondent	Years	+
Insurestat	Insurance status	(1=Insured, 0=Otherwise	+ on yield and fertilizer purchase
Yrsexp	Years of experience	Years	+
Househh	Household head	(1=Yes, 0=No)	+/-
Yrsformeduc	Years of formal education	Years	+
Organblg	Membership of organization	(1=Yes, 0=No)	+
Hhsize	Household size	Number	+/-
totadult	Total number of adults	Number	+/-
totlab	Total amount of money spent on labour	GhanaCedis (GHS)	+/-
noacres1	Number of acres	Acres	+

Continued

Table 1: Continued

livestock	Number of livestock owned	Number	+
crpfailure	Number of years of crop failure due to drought	Years	-
totamt1	Amount of money on weedicide	Ghana Cedis (GHS)	+/-
totnumbfml	Estimated total number of farmland	Acres	+
estcultland	Estimated area cultivated yearly	Acres	+/-
Awareness	Awareness of weather index insurance	(1=Yes, 0=No)	+

CHAPTER FOUR

4.0 Results and Discussion

Discussion of results emanating from the study is presented in this chapter. Descriptive statistics of key variables in the study are presented in section 4.1. Section 4.2 presents the results of adoption of index insurance. Inferential statistics on the effects of index insurance on fertilizer and yield are also discussed in section 4.3.

4.1 Descriptive Statistics

Table 2 presents descriptive statistics of the key variables used in the analysis. The sample of respondents comprised of 35% of purchasers and 65% of non-purchasers of weather-index insurance. The average age of the purchasers is about 43 years whereas that of the non-purchasers is 42 years. Males make up the majority of the respondents in both categories; 76% in the purchasers and 100% in the non-purchasers. This is a reflection of the male dominance in farming especially in the study area. Almost all of the respondents are married, with only one respondent being a widow. About 60% and 63% of the sampled farmers are the heads of their households among the purchasers and non-purchasers respectively. A typical household in the sample has a total of about 14 members, evenly divided between adults and children.

Almost all of the respondents (97.5% purchasers and 99.3% non-purchasers) engage in crop production as their main occupation or primary source of income. About 80% of the purchasers interviewed belong to at least one local association or another (Farmer Base-Organizations, political organizations, youth groups, etc) as compared to 59% of the non-purchasers

In terms of experience in farming, both purchasers and non-purchasers have relatively the same experience of about 24 years. This is not surprising given the average age of the respondents. In terms of formal education, about 81% of the respondents have no formal education and the remaining 19% have at least attained primary education across both categories.

House roofing type, and livestock ownership are measures/indicators of wealth in the study area. Household heads who are able to roof their homes with aluminium or zinc roofing sheets are relatively wealthy. About 54% of the purchasers have at least one room of their homes roofed with aluminium/zinc compared to only 45% of non-purchasers who roofed their homes with aluminium/zinc sheets. A typical household in the purchasers' category owns at least 13 of either sheep, goats or cattle or a combination of these livestock compared to about 9 of these livestock owned by an average household among the non-purchasers.

Table 2 also contains production characteristics of the sampled farmers. Average landholdings among the non-purchasers is 17.39 acres (6.96 hectares), whiles that of the purchasers is 11.4 acres (4.56 hectares). Non-purchasers put an average of 8.95 acres (3.58 hectares) of their landholding into cultivation annually whereas 6.73 acres (2.69 hectares) is cultivated annually by the purchasers. In the 2014-2015 cropping season, a typical purchaser of weather-index insurance in the sample cultivated 1.39 hectares of maize whereas an average non-purchaser in the sample cultivated 1.71 hectares of maize.

In terms of fertilizer use, purchasers of weather-index insurance applied 136.24kg/ha compared to 103.75kg/ha used by non-purchasers. Hence fertilizer use intensity was higher among purchasers than among non-purchasers in the 2014-2015 cropping season. Purchasers also obtained higher maize yield (883.33kg/ha) than non-purchasers (826.05kg/ha).

All the interviewed farmers have experienced crop loss due to drought in the past ten years. On the average, there has been 3 years of crop loss as a result of drought. Awareness of an innovation is a prerequisite for adoption. To this effect, farmers' awareness of weather-index insurance was asked particularly to the non-purchasers during the survey and the results in Table 2 indicate that 34% of the sampled non-purchasers were aware of the innovation.

Table 2: Descriptive and Production Characteristics of Respondents

	PURCHASERS			NON-PURCHASERS		
Variable	**Mean**	**Std.dev**	**N**	**Mean**	**Std.dev**	**N**
Age	42.91	10.68	80	41.13	10.73	150
Male (%)	76.3		80	100		150
Marital Status (1=married, 0=otherwise) (%)	100		80	99		150
Years of experience	24.34	12.32	80	23.78	10.61	150
Household head (%)	60		80	63		150
Formal education (%)	18.75		80	18.67		150
Household size	14.43	7.16	80	13.56	5.81	150
Crop production as main occupation (%)	97.5		80	99.3		150
Belonging to an organization (%)	80	0.40	80	59	0.49	150
Estimated total number of land owned (acres)	11.4	8.64	80	17.39	21.99	150
Estimated total area cultivated yearly (acres)	6.73	6.15	80	8.95	13.89	150
Number of years of crop failure due to drought	3.3	1.28	80	2.97	1.19	150
Awareness of index insurance (%)	100		80	34		150
Total adults in household	6.79	4.08	80	6.98	3.48	150

Continued

Table 2: Continued

Total children in a household	7.85	4.56	80	6.58	3.24	150
Aluminium/zinc roof (%)	53.8		80	45.3		150
Livestock owned	13.29	16.99	80	8.91	12.03	150
Maize plot size (ha)	1.39	1.16	80	1.71	2.06	150
Fertilizer use(kg/ha)	136.24	121.32	80	103.75	97.08	150
Yield (kg/ha)	883.33	683.21	80	826.05	461.76	150

Table 3 presents mean difference test in the outcome variables. There is a statistically significant difference in fertilizer use per hectare between weather-index insurance purchasers and non-purchasers. However, there is no difference statistically, in maize yield between the two groups.

Table 3 Mean difference test by Insurance status

	Mean Difference (Non-insured V Insured)	Std. Err.
Fertilizer use (kg/ha)	-32.49**	14.69
Yield (kg/ha)	-57.28	75.97

*P<0.10 **P<0.05 ***P<0.01

4.2 Factors Determining Weather Insurance Purchase

In this section, a logistic regression is performed to determine the factors that influence farmers' weather insurance purchase decisions. The dependent variable in this analysis is farmers' insurance status, which takes on the value of 1 if the respondent bought weather insurance and 0 otherwise. The explanatory variables included in this analysis include respondent demographics and wealth indicators.

Since the parameter estimates of the binomial logit only provides direction and not probability or magnitude of change, the marginal effects of the parameters are rather discussed in this study. Table 4 presents the marginal effects of the factors that determine weather-insurance purchase among smallholder farmers in northern Ghana.

The results of the logistic regression indicate that membership of an organization, total number of land owned, number of acres cultivated yearly, number of livestock owned, household size, number of adults in a household and awareness of weather-index insurance are the factors that determine weather-index insurance purchase.

Farmers who are members of associations like Farmer Base Organizations (FBOs), political organization, youth groups and other Non-governmental Organizations (NGOs) are about 12% more likely to purchase weather index insurance than farmers who do belong to any form of associations. A visit to the GAIP office revealed that, they actually favour farmers who are in groups to buy the insurance policies since it is easy to market to groups than to individuals. Most of the farmers also got the awareness of weather insurance by virtue of their membership of FBOs.

In terms of household composition, household size and number of adults per household have both got significant but opposite effects on the likelihood of insurance purchase. A unit increase in the size of a household increases the likelihood of the household buying weather insurance by 3.5%. On the contrary, a unit increase in the number of adults within a household lowers the probability of index insurance purchase by 5%. The reasons behind this finding is unclear. A possible reason could be that households with more children feel the impact of crop failure due to drought in terms of feeding the members and therefore like to purchase insurance to help in ex post drought coping management through the payments they will get from the insurance company should there be a drought. Such farmers could be using weather insurance as consumption smoothing strategy.

Number of acres of land owned tend to have negative relationship with the probability of insurance purchase among smallholder farmers in northern Ghana. The logit regression results show that a one acre increase in the number of acres of land owned reduces the likelihood of insurance purchase by 2%. However, as the number of cultivated acres of land increases, the chances of buying weather-index insurance also increase. Specifically, a one acre increase in the size of land cultivated increases the probability of weather insurance purchase by 2%

Awareness of weather index insurance also affects the chances of its purchase positively. The results of the logistic regression analysis show that farmers who are aware of weather index insurance are about 53% more likely to purchase than farmers who are not aware. This is expected and banal because, one needs to be aware of a technology or innovation before he can adopt it. And so if there's no awareness, there will not be purchase.

Number of livestock, which is measure of household wealth, positively influences the chances of insurance purchase. An increase in the number of livestock by one, enhances the likelihood of insurance purchase by 0.7%. This is intuitive because, the purchase of weather index insurance requires payment of money (premium) and therefore it is expected that wealthy farmers will be more able to buy the product than poor farmers.

Table 4 Marginal Effects of Logit Parameter Estimates

Variable	**dy/dx**	**Std.Err.**
Ageresp	0.003	0.005
Yrsexp	0.002	0.005
Househh(*)	-0.07	0.084
Yrsformeduc	0.008	0.012
Organblg (*)	0.12	0.065*
Totnumbfml	-0.02	0.005***
estcultland	0.02	0.007**
Crpfailure	0.04	0.029
Awareness of index insurance(*)	0.53	0.059***

Continued

Table 4: Continued

Livestock	0.007	0.003***
Hhsize	0.035	0.012***
Totadult	-0.05	0.021**

(*) dy/dx is for discrete change of dummy variable from 0 to 1

*P<0.10 **P<0.05 ***P<0.001

4.3 Effects of Weather Index Insurance on Fertilizer Use, and Yield

4.3.1 Endogenous treatment Approach

In order to estimate the effect of weather-index insurance on fertilizer use intensity and maize yield among smallholder farmers, the binary endogenous model (endogenous treatment model) developed by Heckman (1979) and Maddala (1983) was used.

Table 5 presents the results of the endogenous treatment model, which was estimated using the two-step estimating procedure in STATA 13.

The overall fit of the model is good as indicated by a very strong Wald Chi Square. The variable of interest, weather-index insurance has a positive and significant effect on fertilizer use intensity. Weather-index insurance purchase significantly increases fertilizer use among the insured farmers by about 43 kg/ha. Awel and Azomahou (2014) also find similar results among Ethiopian farmers.

Other factors that affect fertilizer use intensity are, being household head and amount of money (GHS) spent on labour.

Farmers who are the heads of their households applied less fertilizer compared to their counterparts who are not heads of their homes. This could be due to household heads having more financial burden in terms of taking care of the household especially during the growing season, which makes them cash-strap and hence they are not able to buy more fertilizer. Labour expenditure has a positive influence on fertilizer use intensity. Fertilizer application is a labour demanding task especially in the study area and among the study population who carry out most of the farm activities manually. Hence it is not surprising that more labour expenditure on farm activities, for which fertilizer application is among, results in high intensity of fertilizer application.

Table 5 also has the regression results of weather-index insurance on maize yield/ha. The two-step estimating procedure was again used for the estimation.

Again, the Wald Chi Square of the model is very significant, indicating that the combined effects of the regressors in the model are different from zero. Weather-index insurance had a positive but insignificant effect on maize yield. This means that any observed differences in yield between the purchasers and non-purchasers of weather-index insurance wa due to chance. Awel and Azomahou (2014) had similar results. However there were other factors that helped explain maize yield among smallholder farmers in northern Ghana. These include, age of respondents, experience of household respondents in farming, household size, total number of adults in the household, and quantity of fertilizer applied per hectare.

Age had a negative effect on maize yield, which is counterintuitive because it is expected that older farmers will have more experience and therefore get more yield. As expected, experience of farmers has a significant and positive effect on maize yield. This means that, more experienced farmers harvest more maize per hectare than less experienced ones, all other factors held constant. Total household size has a positive effect on yield but number of adults in a household has a negative effect on yield. It was however expected that, both household size and total number of adults in a household will have positive influence on yield because larger number of adults in a household for smallholder farmers means more labour force for larger farms. This is in contrast to the finding of Dalton et al (2011), who found positive effect on yield of number of adults in a household. Quantity of fertilizer per hectare applied is also found to have significant effect on maize yield.

The selection equation results is very consistent with the results from the logit regression in Table 4 in terms of the variables that determine weather-index insurance purchase.

The coefficient of lamda is not significant indicating that the use of the selection equation is not necessary.

Table 5 Endogenous Treatment Regression Model Results

Outcome Equation	Fertilizer(kg/ha)		Yield (kg/ha)	
Variable	**Coeff.**	**Standard.Err**	**Coeff.**	**Stand.Erro**
Ageresp	-0.13	1.06	-16.34	5.23***
Yrsexp	-0.76	0.99	14.79	4.88***
Yrsformeduc	0.53	2.14	7.48	10.47
Househh	-35.78	15.85**	-71.23	78.61
HHsize	0.50	1.21	26.11	11.59**
Totadult			-42.15	19.75**
Organblg	11.28	15.38	-12.59	75.20
Crpfailure	-5.43	5.64	-8.16	27.68
Hect	0.64	4.01	-4.25	19.63
livestock	0.44	0.56	-1.89	2.75
totlabperha	0.14	0.08*	-0.11	0.38
totamtperha	0.06	0.10	-0.26	0.51
fertperha			1.67	0.33***
insurestat	43.06	25.91*	16.13	127.63
Constant	122.71	41.94	1022.51	206.11***
Treatment Equation (Insurestat)				
Ageresp	0.01	0.02	0.01	0.02
Yrsexp	-0.001	0.15	-0.001	0.15
Yrsformeduc	0.02	0.03	0.02	0.03
Organblg	0.32	0.23	0.32	0.23
Totnumbfml	-0.05	0.01***	-0.05	0.01***
estcultland	0.05	0.02**	0.05	0.02**
Crpfailurre	0.15	0.08*	0.15	0.08*
Aware of index insurance	1.75	0.24***	1.75	0.24***
Livestock	0.02	0.008**	0.02	0.008**
HHsize	0.02	0.02	0.02	0.02
Constant	-2.84	0.65***	-2.84	0.65***
N	230		230	
Hazard				
Lamda	-12.89	18.03	-18.33	88.33
Wald Chi2	43.95		69.41	
Prob>Chi2	0.001		0.000	
Rho	-0.13		-0.04	
sigma	101.05		493.45	

- *P<0.10 **P<0.05 ***P<0.001

4.3.2 Inverse Probability Weighted Regression Approach

Following the assumption that selection bias is due to observables, I used the Inverse Probability Weighted Regression Adjustment (IPWRA) to estimate treatment effects. Details of this approach are explained in chapter three.

Based on the results of Table 6, there was no statistically significant impact of purchasing weather-index insurance on technology adoption in terms of fertilizer use. This is in contrast to the finding by Awel and Azomahou (2014) who find a statistically positive impact of weather insurance purchase on fertilizer use among Ethiopian farmers using similar estimation procedure.

Again, there was no statistically significant effect of buying weather-index insurance on yield of farmers in the study area, and that any observed differences in yield between purchasers and non-purchasers of weather-index insurance was6 purely due to chance. Awel and Azomahou (2014) again had a contrary results of weather-index insurance purchase on yield.

Table 6 Results of Inverse Probability Weighted Regression Adjustment (IPWRA) Estimation

	Average treatment effect (ATE)	Std. Err.
Fertilizer use (kg/ha)	14.20	14.86
Yield (kg)	-58.47	97.34
Total Observations	230	

*P<0.10 **P<0.05 ***P<0.001

CHAPTER FIVE

5.1 Summary and Conclusion

The study sought to examine the effects of weather-index insurance purchase on fertilizer use intensity and on yield among smallholder farmers in northern Ghana. To achieve this aim, quantitative methods were used to analyze data gathered through semi-structured household interviews.

A survey of 230 farmers were interviewed, including 80 purchasers and 150 non-purchasers of weather-index insurance using semi-structured questionnaires. The respondents comprised of only males (100%) in the non-purchasers' category whereas there were about 24% female respondents among the purchasers. A typical farmer among the non-purchasers was about 41 years old whiles average age among the purchasers was 43 years. Farmers across both categories had the same level of experience (24 years) in farming. Only 38% (19% purchasers and 19% non-purchasers) of the farmers interviewed had any form of formal education.

Average size of household in the entire sample is 14, evenly divided between adults and children. Crop production is the main occupation of the farmers in the sample. Average livestock size owned by a typical purchaser of weather-index insurance was 13, compared to 9 owned by an average non-purchaser.

In the 2014-2015 cropping season, average land size put under maize production by weather-index insurance purchasers was 1.39 hectares against 1.71 hectares by non-purchasers. In the same cropping season, purchasers of weather-index insurance used fertilizer quantity of 136 kg/ha and obtained maize yield of about 883.33kg/ha compared to non-purchasers who used 103.75kg/ha of fertilizer and had average yield of about 826.05kg/ha. A mean difference test in the outcome indicators (fertilizer use and yield) between the two groups indicated a significant difference in fertilizer use intensity but not in maize yield.

Results of a logistic regression revealed that membership of an organization, total number of land owned, number of acres cultivated yearly, number of livestock owned, household size, number of adults in a household and awareness of weather index insurance are the factors that determine weather-index insurance purchase in northern Ghana.

To measure the impact of weather-index insurance purchase on fertilizer use intensity and on maize yield, the endogenous treatment-regression model and the inverse probability weighted regression adjustment (IPWRA) estimation procedure were used. The endogenous treatment-regression model is based on the assumption that selection into treatment is based on both observable and unobservable covariates while the IPWRA is based on the assumption that selection is based only on observable covariates. Results of the endogenous treatment-regression model showed that purchase of weather-index insurance has a positive and significant impact on fertilizer use intensity among farmers in northern Ghana. The selection equation component of the endogenous treatment-regression model produced consistent results with the logistic regression model on the factors that influence weather-index insurance purchase in the study area. However the IPWRA specification showed a positive but insignificant effect of weather-index insurance purchase on fertilizer use intensity. On yield, both the endogenous treatment-regression model and the IPWRA estimation procedure showed no significant impact of weather-index insurance purchase.

In conclusion, the purchase of weather-index insurance has been found to have a positive and significant impact on fertilizer use intensity but not on yield among smallholder maize farmers in northern Ghana in this study.

As a recommendation, the government of Ghana can use weather-index insurance as a strategy to increase farm input use by smallholder farmers in northern Ghana through provision of insurance premium subsidies to farmers.

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APPENDIX A

QUESTIONNAIRE ON EFFECTS ON INDEX INSURANCE

Questionniare I.D:……………………., Date of Interview: _ _/ _ _/2015

Name of
Enumerator:………………………………………………………………………………………

District:………………………, DistID:……………. Community Name:……………………
ComCode:……..

PART A: DEMOGRAPHICS OF RESPONDENTS/HOUSEHOLD

A1. Name of respondent………………………………………………………

A2. Age (years):…………… A3. Gender: 1. Male [ ] 2. Female [ ]

A4. Marital status: 1. Married [ ] 2. Single [ ] 3. Widowed [ ] 4. Divorced []

A5. Years of experience in farming…………………………………

A6. Is respondent the head of HH? 1. Yes [ ] 2. No [ ]

A7. Highest level of formal education attained: 1. Primary [ ] 2. JHS [ ] 3. SHS [ ] 4. Tertiary [ ]

A8. Number of years of formal education attained:…………………….

A9. Number of adult males(18 yrs and above) in the household:………………

A10. Number of adult females (18 yrs and above) in the household:……………

A11. Number of male children (18 yrs and below) in the household:…………

A12. Number of female children (18 yrs and below) in the household:…………

A13. What is the main occupation of the respondent? .1 Crop production [ ] 2. Livestock rearing [ ] 3. Petty trading [ ] 4. Craftsmanship [ ] 5. Labour [ ] 6. Permanent employment [ ]

A14. Which organization do you belong? 1. FBO [ ] 2. Youth group [ ] 3. Political organization [ ] 4. NGO [ ] 5. Do not belong to any organization [ ]

PART B: HOUSEHOLD ASSETS AND RESOURCES

B1 PRIMARY RESIDENCE CONSTRUCTION

1. For your primary residence, what is the roof made of?	2. What is the floor made of?	3. What are the walls made of?	4. Are the walls painted?	5. Does the house have a latrine either outside or inside the house?	6. Does the house have electricity?	8. What type of **primary** water access does the house have?
1=Zinc 2=grass/leaves/bamboo 3=wood/earth 4=other (specify)	1=earth 2=brick 3=board/wooden 4=cement/tile 5=other (specify)	1=earth/mud 2=earthen brick 3=board 4=cement brick 5=stone 6=other (specify)	1=No 2=Yes	1=No 2=Yes	1=No 2=Yes	1=nearby well/public tap[1] 2=distant well/publlic tap 3=nearby river, spring, pond 4=distant river, spring, pond
code	code	code	code	code	code	code

B2. Main source of fuel used for cooking. 1. Bio waste [ ] 2. Charcoal [ ] 3. Firewood [ ] 4. Gas [ ] 5. Electricity [ ] 6. Other(Specify……………………..)

B3. Mode of disposal of refuse. 1. Collected by company [ ] 2. Dumped by household at a location [ ] 3. Burned by household [ ] 4. Buried by household [ ]

B4. How many of the following assets/livestock does the household own?

Asset	Quantity	Estimated current Value (GH ₵)	Asset	Quantity	Estimated current Value (GH ₵)
Motor vehicle			Generator		
Motor cycle			Mobile Phones		
Bicycle			Fan		
Tractor			Sewing machine		
Draft animals**			Television		
Cattle			Radio		
Goat					
Sheep					
Chicken					
Cutlass					
Hoe					
Sickle					
Knapsack sprayer					

PART C: LAND HOLDINGS

C1. What is the estimated total number of farmland you own? ………….acres

C2. What is the estimated land you cultivated in 203-2014 season?

…………………acres

C3. Please list(*In decreasing order of importance*) the five most important crops you grow

i………………………………………. ii………………………………………

iii……………………………………

iv………………………………… v……………………………………

PART D: RISK AND WEATHER INDEX-INSURANCE

D1. Have you experienced any crop loss due to drought in the past 10 years?

1. Yes [ ] 2. No [ ]

D2. How many times have you experienced crop failure due to drought in the past 10 years? ___________

D3. What is the effect of drought on your household (***Tick all that apply***)? 1. Unable to feed my household [ ] 2. Unable to send children to school [ ] 3. Loss of livestock [ ] 4. Water scarcity [ ] 5. Other___________________________

D4. How do you cope with the effects of drought (***Tick as many as applicable***)? 1. Reduce consumption [ ] 2. Ration food [ ] 3. Buy more food [ ] 4. Sell assets to buy food [ ] 5.Sell livestock to buy food [ ] 6. Work off farm to generate income [ ] 8.Other________________________________

D5. Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? 1. Very willing to take risks [ ] 2. Willing to take risks [ ] 3. Indifferent to taking risks [ ] 4. Not willing to take risks [ ] 5. Not at all willing to take risks [ ]

D6. Would you rather prefer to receive GHC 10 today or GHC 15 in one month time?

1. GHC 10 today [ ] 2. GHC 15 in one month [ ] 3. Indifferent [ ]

D7. Are you aware of rainfall/drought-index insurance? 1. Yes [ ] 2. No [ ]

If No, to QD5, please skip to part E

D8.If yes to QD7 above, have you ever bought index insurance to cover your crops? 1. Yes [ ] 2. No [ ]

D9. If No to QD8 above, why have you not bought index insurance? 1. Lack of funds [ ] 2. No idea of how it works [ ] 3. It doesn't pay [ ] 4.Just don't like it [ ]

If you have bought index insurance before please answer the following questions

D10. Which year did you first buy index insurance? _______

D11. If you bought index insurance in the previous years before 2013-2014 crop season, did you repeat the purchase of index insurance at least once in the subsequent crop seasons? 1. Yes [ ] 2. No [ ]

D12. If Yes to QD11 above, why did you repeat the purchase? 1. Had pay-out when I bought the insurance in the first year [ ] 2. Had a good harvest [ ] 3. Other________

D13. If No to QD11 above, why did you not repeat the purchase in the subsequent seasons? 1. Did not get a pay-out when I suffered a loss [ ] 2. High premium rate [ ] 3. Lack of money [ ] 4. I didn't see the benefits of having insurance [ ] 5. Other______

D14. Which crop did you buy index insurance to cover?   1. Maize [   ]

2.Soybean [   ] 3. Rice [ ]   4. Other…………

D15. Did you choose the crop you wanted to cover or the insurance company has the crops it covers? 1. I choose the crop I want to cover [ ] 2. Insurance Co choose the crop [ ]

D16. If you decide which crop to cover, why did you choose to cover this particular crop?(**Please refer to the answer from QD12**) 1. It is more susceptible to drought [   ]   2. It is my staple crop [ ] 3.It is a cash crop [   ]   4. I plant more acres of this crop [   ]   5. Other____________________________

D17. Did you buy index insurance to cover all the acreages of this crop you planted that year? 1. All acreages of this crop were covered [ ]   2. Only some acres were covered [ ]

D18. If you did not cover all acres of this crop, why?

____

D17. Did you cultivate all acreages of this crop on the same plot/parcel?

1. All acreages cultivated were on the same parcel/plot [ ] 2. All acreages cultivated were at different locations(***this could even be in differenttowns***)

D19. What factors do you consider when deciding to buy weather insurance? 1. Trustworthy of insurance company [ ] 2. Previous payout [ ] 3. Premium price 4. Basis risk [ ]

D20. Please we will like to find out how you managed your insured and uninsured acres/parcels of this crop (Please fill only the insured if the respondent did not have acreages of the crop not insured)

Crop Season	**Name of Crop**	**Crop Status**	**No. of Acres**	**Qty of Fertilizer applied (kg)**		**Seed**			**Weedicide/Herbicide (litres/kg)**			**Yield (kg)**	**Labour**		
													Amt spent on Hired labour	**Amt on Family labour**	**Amt on Exch.labour**
				1st application	**2nd application**	**Source(code)**	**Qty (kg)**	**Unit price/kg**	**1st spray**	**2nd spray**	**Total Amt(GHS)**		GHS	GHS	GHS
2014		**Insured**													
		Uninsured													
2013		**Insured**													
		Uninsured													
2012		**Insured**													
		Uninsured													
2011		**Insured**													
		Uninsured													

(SOURCE OF SEED)

1=Retained seed

2=Bought from farmer

PAART E: For Farmers Who Don't know or Didn't Buy Index Insurance

Index-Insurance is a program where you protect yourself against future possible disasters such as drought. You protect yourself by paying a small amount against a coverage you select, you desire and you consider adequate. In the event of drought occurring then you are assured/guaranteed of compensation based on your coverage you initially declared. A rainfall gauge is located at a nearby rainfall station to record the amount of rainfall. If the gauge records an insuffeicient rainfall, then you will get payout even if you don't suffer drought in your farm. Conversely, if you have drought in your farm and the rainfall gauge records sufficient rainfall then you will not be paid. Example is the HEALTH INSURANCE.

E1. Would you buy such a policy for your crops if it is available? 1. Yes [ ] 2. No [ ]

E2. Which of your crops would you buy the insurance to cover? 1. Maize [ ] 2. Rice [ ] 3. Soybean [ ] 4. Millet [ ] 5. Peanut [ ] 6. Other______________________

E3. Why would you prefer to buy insurance for this particular crop(s)? 1. It is more susceptible to drought [ ] 2. It is my staple crop [ ] 3.It is a cash crop[ ]

4. I plant more acres of this crop [ ] 5.

Other____

E4. Would you be willing to pay GHS_________ as premium in order to cover one acre of your field? {*a*.GHS_10________

{*b*.GHS_15________
{*c*.GHS_20________

Depending on what initial PRICE BID (a-e) you offer the farmer and farmer's response to it, ITERATE the bid **UPWARDS** if farmer's response is YES or **DOWNWARDS** if response is NO, continue asking/eliciting farmer's WTP for HIGHER/LOWER amounts until he says NO/YES. Show this in Table below:

Premium WTP (for coverage of 1 acre)	Check with a tick for YES and X for NO.
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	

E5. How would you like the weather insurance package? 1. Only insurance premium [ ] 2. Insurance +input loan [ ] 3. Insurance + cash loan [ ] 4. Other__________________________

E6. Will you change your management practices simply because you buy a weather insurance? 1. Yes [ ] 2. No [ ]

E7. How will your management practices change if yes to E6? (Tick all that apply) 1. Increase the quantity of fertilizer [ ] 2. Start using improved seeds [ ] 3. Increase the size of my farm

4. Other___________________________________

E8. Please we will like to find out how you managed your crop for the past years

Crop Season	Name of Crop	Crop Status	No. of Acres	Qty of Fertilizer applied (kg)		Seed			Weedicide/Herbicide (litres/kg)			Yield (kg)	Labour		
													Amt spent on Hired labour	Amt on Family labour	Amt on Exch.labour
				1st application	2nd application	Source(code)	Qty (kg)	Unit price/kg	1st spray	2nd spray	Total Amt(GHS)		GHS	GHS	GHS
2014															
2013															
2012															
2011															