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EFFECTS OF WEATHER-INDEX INSURANCE: THE CASE OF SMALLHOLDER MAIZE FARMERS IN NORTHERN GHANA

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Abstract

The study investigates the effect of weather-index insurance on intensity of fertilizer use and yields among 230 smallholder maize farmers in Northern Region of Ghana. Out of the total sample of selected farmers, about 35% purchased the insurance. Using an endogenous treatment regression model, the study showed that weather-index insurance purchase increased the intensity of fertilizer use but did not have a significant effect on maize yield. Past experience of crop failure due to drought, livestock ownership as well as the total area of land owned explained weather-index insurance purchase in the study area. Based on the results of this study, the Government of Ghana can use weather-index insurance as a policy tool to increase the use of fertilizer by smallholder maize farmers.
Key words: Fertilizer, smallholder farmers, weather-index insurance, yield
JEL Codes: Q12, Q16, Q18

1. Introduction

Maize is the most important cereal crop in Ghana both in terms of crop area and utilization especially in the Northern region. It accounts for about 55% of grain output in Ghana (Angelucci, 2012). Productivity of maize has been increasing over the years even though still very low with current yield averaging 1.7t/ha far below the potential of 4-6t/ha (MoFA, 2013). According to many studies and experts, Ghana's slow productivity growth in maize is caused by low adoption of productivity-enhancing technologies, including improved varieties and management practices, and low use of purchased inputs, especially fertilizer (Ragasa et al., 2013; MoFA, 2010).

Chemical fertilizer application has been identified as an effective means of increasing crop productivity. Fertilizers increase productivity on crop farms (Sauer & Tchale, 2009), increase investment returns in crop production systems (Olagunju & Salimonu, 2010), and ultimately enhance household, national, and global food availability (Spiertz, 2010). Despite its benefits, fertilizer application in Ghana is still very low. According to World Bank (2015), fertilizer application per hectare of arable land was 38.5kg in 2013. Ragasa et al. (2013) found that, maize farmers who applied fertilizer in the 2012 cropping season, applied an average of 47kg/ha of nitrogen and about 20kg/ha of phosphorus fertilizer. That figure is still below the recommended rate of 90kg/ha of nitrogen for maize plots that are continuously cropped (Ragasa et al., 2013). Many factors have been cited as responsible for the low use of fertilizer including lack of crop insurance (Druilhe & Barreiro-Hurlé, 2012).

Over the past years, Government of Ghana has developed measures to increase fertilizer use in the country. Notable among these measures include the fertilizer subsidy program introduced in 2008; where a fraction of the price of fertilizer is absorbed by government in order to make the retail price affordable to farmers. However such a policy has its drawbacks including inefficiencies such as, adverse selection of program beneficiaries, impacting input and output markets and interacting with trade policies (Druilhe & Barreiro-Hurlé, 2012).

In search of alternatives to enhancing farm input use, policy makers and development partners have identified weather-index insurance as an instrument that can enhance farm investment in general and fertilizer use in particular. Proponents of weather-index insurance argue that uninsured risk is one of the major reasons why smallholder farmers fail to invest on their farms in terms of adoption of improved technologies that often come with a cost and risk; and that by taking this risk from farmers, they will be able to find resources to invest on their farms. Karlan, Osei, Osei-Akoto, and Udry (2014) for example find that uninsured risk is a binding constraint on farmer investment: when provided with insurance against the primary catastrophic risk they face, farmers are able to find resources to increase expenditure on their farms. Druilhe and Barreiro-Hurlé (2012) cited the lack of crop insurance as one of the profitability constraints of fertilizer use in Africa. According to Miranda and Farrin (2012), weather-based index insurance has been offered as alternative method for increasing uptake of agricultural technology.

The prospects of introducing weather-index insurance to manage smallholder farmers' risks and encourage farm investment in developing countries has excited many in academia as well as development practitioners (Awel & Azomahou, 2014); such that within a decade there has been many weather-index insurance pilot programs in Kenya, China, Ethiopia and India (Cole, Gine & Vickery, 2014; Janzen & Carter, 2013). 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 scheme is commercial and not on pilot base. The weather-insurance product targeted only smallholder maize farmers with farm sizes less than 20 ha at its inception.

Despite the excitement about the prospects of weather-index insurance to encourage farm investment, there has been little research to quantify its benefits. Morduch (2006) observes that "the expanding gaggle of micro insurance advocates are ahead of the available evidence on insurance impacts". Cole, Bastian, Vyas, Wendel, and Stein (2012) also observe that 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 index insurance and thus recommend that research on how access to weather-index insurance affects agricultural investment needs to be extended. This paper contributes to the literature on the impacts of weather-index insurance by examining how purchasing weather-index insurance affects the amount of fertilizer use on maize farms and ultimately, maize yield. The methodology for achieving this objective is described in the next section. Section 3 presents the results and discussions from the study and the conclusion and recommendations are presented in section 4.

2. Methodology

2.1 The Rubin Causal Model (RCM)/ The Counterfactual Setting Framework

The intuition behind the Rubin causal model is that, each 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.

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

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

$$Y_i = Y_{0i} + (Y_{1i} - Y_{0i})D_i, \quad (2)$$

where $Y_{1i} - Y_{0i}$ is the causal effect of the treatment for an individual agent.

However in practice, we never get to observe both potential outcomes for an individual agent. 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 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:

$$E[Y_i|D_i = 1] - E[Y_i|D_i = 0] \quad (3)$$

Equation (3) can be re-written as:

$$\{E[Y_{1i}|D_i{=}1]-E[Y_{0i}|D_i{=}1]\}+\{E[Y_{0i}|D_i{=}1]-E[Y_{0i}|D_i{=}0]\} \quad (4)$$

The term $\{E[Y_{1i}|D_i{=}1]-E[Y_{0i}|D_i{=}1]\}$ is the average effect of the treatment on those who took part in the treatment (ATET). This is the average difference between the observed outcomes of the treated and what would their observed outcomes be if they had not been treated. However the ATET comes along with, $E[Y_{0i}|D_i = 1] - E[Y_{0i}|D_i = 0]$, which is the difference in average expected outputs between those who were treated and those were not treated. This difference is the "self- selection bias", which must be gotten rid off in order to estimate the actual effect of the treatment. As Angrist, and Pischke (2008) put it, 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 propensity score matching approach proposed by Rosenbaum and Rubin (1983) has been used to measure impacts of adoption of technologies on outcomes when there is self-selection bias issue (e.g., Martey, Dogbe, Etwire, & Wiredu, 2015; Amare, Asfaw, & Shiferaw, 2012). However a major drawback of the propensity score matching approach is that it assumes selection is based on observable covariates and hence produces bias results when there unobservable factors determining selection. The Heckman selection model has also been used to deal with the self-selection bias issue. However the Heckman selection model is not appropriate in our case where we observe the outcomes (yield and fertilizer use) of both purchasers and non-purchasers of weather-index insurance. In this study, we employed the endogenous treatment regression model to correct the selection bias. This model allows for selection on unobservable factors in addition to observable factors.

2.2 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 unobservable factors that affect the treatment and the unobservable factors that affect the potential outcomes. Formally, the endogenous-treatment model is composed of an equation for the outcome and equation for treatment assignment as presented below.

$$Y_i = X_i\beta + \gamma D_i + \mu_i \quad (5)$$

$$D_i^* = Z_i\gamma + \epsilon_i, \quad (6)$$

Where, D_i is a latent variable such that,

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

Y_i is the outcome variable (in this case fertilizer use intensity; maize yield). X_i is a vector of covariates used to model the outcome equation and Z_i is a vector covariates used to model treatment assignment.

Equation (5) can be generalized for the treatment and control groups as shown below:

$$y_{1i} = x'\beta_i + \mu_{1i}, \quad (7)$$

$$y_{0i} = x'\beta_0 + \mu_{0i}, \quad (8)$$

y_{1i} is the quantity of fertilizer per hectare or maize yield per hectare by farmers who purchased weather-index insurance.

y_{0i} is the quantity of fertilizer per hectare or maize yield per hectare by farmers who did not purchase weather-index insurance.

The underlying assumption is that$E[\mu_1|x, z] = E[\mu_0|x, z] = 0$.

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

$$y_{1i} - E[y_{0i}|D_i^* = 1] = y_{1i} - x'\beta_0 + \sigma_{0\epsilon}\frac{\phi(z'\gamma)}{\left(1-\Phi(z_i'\gamma)\right)}, \quad (9)$$

Equation (9) can be re-written as

$$E[y_{1i}|D_i = 1] - E[y_{0i}|D_i = 1] = x_i'(\beta_1 - \beta_0) + (\sigma_{0\epsilon} - \sigma_{1\epsilon})\frac{\phi(z'\gamma)}{\Phi(z_i'\gamma)}, \quad (10)$$

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

Equation (10) can then be estimated by maximum likelihood or two-step semiparametric procedure.

2.3 Data and Sampling

The data for this study was collected through informal interviews of sampled maize 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 in 2013. 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 in Tamale. Ten (10) communities were randomly selected from the list of communities obtained from ADVANCE. Within each selected community, 15 maize producing households who did not buy weather-index insurance and eight (8) maize producing households who bought weather-index insurance were randomly selected. Overall, data on 230 maize producing households comprising 80 who bought insurance and 150 who did not buy insurance in 2013 was used for the analysis. See Table 1 for definition of variables used in the regression analysis.

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 use
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	Ghana Cedis (GHS)	+/-
noacres1	Number of acres of maize cultivated	Acres	+
livestock	Number of livestock owned	Number	+
crpfailure	Number of years of crop failure due to drought	Years	-
totamt1	Amount of money spent on weedicide	Ghana Cedis (GHS)	+/-
totnumbfml	Estimated total area farmland owned	Acres	+
estcultland	Estimated total area cultivated yearly	Acres	+/-
Awareness	Awareness of weather index insurance	(1=Yes, 0=No)	+

3. Results and Discussion

3.1 Descriptive Statistics

Table 2 presents descriptive statistics of the key variables used in the analysis. The sample of respondents comprised 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 aluminum or zinc roofing sheets are relatively wealthy. About 54% of the purchasers have at least one room of their homes roofed with aluminum/zinc compared to only 45% of non-purchasers who roofed their homes with aluminum/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. 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
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
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 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 three 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.

3.2 Effects of Weather-Index Insurance Purchase on Fertilizer Use Intensity and on yield

In estimating the effect of weather-index insurance purchase on fertilizer use intensity and on yield among smallholder maize farmers, the binary endogenous model (Maddala, 1983; Heckman, 1979) was used. The results of the model are presented in Table 3 and also discussed in the sub-sections below. The model has two parts; the treatment assignment part and the outcome part. The treatment part examines factors that influence treatment assignment and the outcome part determines factors including the treatment variable that influence the outcome.

3.2.1 Factors determining weather-index insurance purchase

The results of the treatment part of the model indicate that, total area of land owned, number of acres cultivated annually, number of livestock owned, past experience of crop failure due to drought, and awareness of weather-index insurance are the factors that determine weather-index insurance purchase among smallholder farmers in Northern region.

Total area of land owned by a household has a negative relationship with the probability of weather-index insurance purchase among smallholder farmers in Northern region, but area of cultivated land has a positive impact on weather-index insurance purchase. Our finding of land ownership on weather-index insurance purchase is consistent with the finding of Cole *et al.*(2014) The implication is that farmers who have the ability to till more land are more likely to purchase weather-index insurance than farmers who do not have the capacity to cultivate more land even though both categories of farmers may have many hectares of arable land. Also, consistent with a priori expectation, farmers' awareness also has a positive effect on the probability of weather-index insurance purchase. This implies that the more farmers become aware of weather-index insurance, the higher the probability of them adopting or purchasing the policy. This finding is consistent with that of Mohammed and Ortmann (2005). Again, household wealth, proxied by the number of livestock owned, has a positive correlation with the probability of weather-index insurance purchase. This is intuitive because, the purchase of weather-index insurance requires payment of money (premium) and therefore wealthy farmers will be more able to buy the product than poor farmers. Our finding is similar to previous findings (Awel & Azomahou, 2015; Cole, Paulson, & Shastry, 2012). Furthermore, past experience of crop failure as a result of drought has a positive effect on weather-index insurance purchase among smallholder maize farmers in Northern region. This implies that households who have experienced crop loss due to drought have higher probability of purchasing weather-index insurance than households who do not have the experience of crop loss due to drought.

3.2.2 Effects of weather-index insurance purchase on fertilizer use intensity and on maize yield

Results of the outcome part of the endogenous regression model are discussed in this sub-section. We considered two outcomes; fertilizer use intensity and maize yield.

The overall fit of the fertilizer use intensity outcome model is good as indicated by a very strong Wald Chi Square. Our variable of interest, weather-index insurance purchase, 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. Our finding is consistent with other findings that weather-index insurance purchase has a positive impact on fertilizer use intensity (Awel & Azomahou, 2014) and on quantity of fertilizer demanded (Gebrehiwot, 2015).

Other factors found to determine fertilizer use intensity are, being a household head and the expenditure on farm labour. Farmers who are the heads of their households applied less fertilizer compared to farmers 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-trap and hence they are not able to buy more fertilizer. Also, farm labour expenditure has a positive influence on fertilizer use intensity. This finding is consistent with the finding of Wiredu, Zeller, and Diagne (2015). Fertilizer application is a labour intensive task especially in the Northern region and hence it is not surprising that more labour expenditure on farm activities, for which fertilizer application is among, results in high intensity of fertilizer use.

Again, the Wald Chi Square of the maize yield model is very significant, indicating that the combined effects of the regressors in the model are statistically different from zero. Weather-index insurance purchase has 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 is due to chance. This finding corroborates Awel and Azomahou (2014). Other factors that help explain maize yield among smallholder maize farmers in Northern region include, age of farmers, experience of in farming, household size, number of adults in a household, and quantity of fertilizer applied per hectare.

Age has a negative effect on maize yield. The implication is that younger maize farmers get more yield than older farmers. This is plausible because older farmers tend to stick to traditional farming methods (Asiedu-Darko, 2014) which often result in low yields. As expected, experience of farmers in maize farming 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. Household size is also found to have a positive effect on maize yield but number of adults in a household has a negative effect on yield. However, the expectation is that, both household size and number of adults in a household will have a positive influence on maize yield because larger number of adults in a household for smallholder farmers implies more labour force for larger farms. This finding is in contrast to the finding of Dalton, Lilja, Johnson, and Howeler (2011). Quantity of fertilizer applied per hectare is also found to have a significant effect on maize yield.

Table 3. 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	

Notes: *P<0.10 **P<0.05 ***P<0.001

4. Conclusion and Recommendation

This study sought to investigate the effect purchasing weather-index insurance has on fertilizer use intensity and on yield of maize farmers in the Northern region of Ghana. The effect of weather-index insurance purchase on farm outcomes is mixed. Whiles weather-index insurance purchase has a positive impact on fertilizer use intensity, its effect on maize yield is insignificant. The increase in fertilizer use may not be enough to affect yield significantly, hence the insignificant effect of weather-index insurance on yield. The study also produced factors that determine smallholder maize farmers' decision to purchase weather-index insurance. These include farmers' past experiences of crop loss due to drought, household wealth (proxied by livestock ownership) as well as total area of land owned by farmers. Farmers' knowledge of weather-index insurance and cultivated area also determine weather-index insurance purchase.

Based on the findings of this paper, we recommend that further research be conducted to fully examine factors affecting weather-index insurance purchase. We again recommend further research to ascertain the true effect of weather-index insurance purchase on crop yield in Northern region. Given that weather-index insurance purchase leads to increase use of fertilizer among smallholder farmers in Northern region of Ghana, government can adopt the product in addition to the fertilizer subsidy program.

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References

Amare, M., Asfaw, S. & Shiferaw, B. (2012). Welfare impacts of maize-pigeon-pea intensification in Tanzania. *Agricultural Economics 43* (1): 27-43

Angelucci, F. (2012). *Analysis of incentives and disincentives for maize in Ghana*. Technical notes series, MAFAP, FAO, Rome.

Angrist, J.D. & Pischke, J. (2008). *Mostly harmless econometrics: an empiricist's companion*. Princeton University press.

Asiedu-Darko, E. (2014). Effects of gender, education and age on the adoption of agricultural technologies in Ashanti, Northern and Eastern regions of Ghana. *Journal of Applied Science and Research 2* (1): 112-118

Awel, Y. & Azomahou, T. (2014). *Productivity and welfare effects of weather index insurance: quasi-exxperimental evidence.* Paper read at the 10th International Microinsurance Conference, 11-13 Novermber, Mexico City, Mexico.

Awel, Y. & Azomahou, T. (2015). *Risk preference or financial literacy? Behavioural experiment on index insurance demand*. UNU-MERIT working paper No. 2015-005

Cole, S., Bastian, G., Vyas, S., Wendel, C. & Stein, D. (2012). *The effectiveness of index-based micro-insurance in helping smallholders manage weather-related risks*. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Cole, S., Paulson, A. & Shastry, G. (2012). *Smart money: the effect of education on financial behaviour*. Working paper No. 09-071, Harvard Business School.

Cole, S., Gine, X. & Vickery, J. (2014). *How does risk management influence production decisions? Evidence from a field experiment*. Working Paper No. 13-080, Harvard Business School, Harvard University.

Dalton, T.J., Lilja, N.K., Johnson, N. & Howeler, R. (2011). Farmer participatory research and soil conservation in Southeast Asian cassava systems. *World Development 39 (12):* 2176-2186. doi:10.1016/j.worlddev.2011.05.011

Druilhe, Z. & Barreiro-Hurlé, J. (2012). *Fertilizer subsidies in sub-Saharan Africa*. ESA Working paper No. 12-04. FAO, Rome.

Gebrehiwot, D. B. (2015). Impact of weather index insurance on household demand for fertilizer in Tigray region. *Ethiopian Journal of Business and Economics 5* (1)

Heckman, J. J. (1978). Dummy endogenous variables in a simultaneous equation system. *Econometrica 46*: 931-959

Janzen, S. A. & Carter, M. R. (2013). *The impact of microinsurance on consumption smoothing and asset protection: evidence from a drought in Kenya*. A selected paper prepared for presentation at the AAEA & CAES joint annual meeting, 4-6 August, Washington, DC.

Karlan, D., Osei, R., Osei-Akoto, I. & Udry, C. (2014). Agricultural decisions after relaxing credit and risk constraints. *The Quarterly Journal of Economics 129* (2): 597-652

Maddala, G. S. (1983). *Limited-dependent and qualitative variables in econometrics*, Cambridge University Press.

Martey, E., Dogbe, W., Etwire, P. M. & Wiredu, A. N. (2015). Impact of farmer mentorship project on farm efficiency and income in rural Ghana. *Journal of Agricultural Sciences 7* (10): 79-93. http://dx.doi.org/10.5539/jas.v7n10p79

Ministry of Food and Agriculture (MoFA). (2013). *Agriculture in Ghana: Facts and Figures (2012)*. Statistics, Research Information Directorate.

Ministry of Food and Agriculture (MoFA). (2010). *Agriculture in Ghana: Facts and Figures (2009).* Statistics, Research Information Directorate.

Miranda, M. J. & Farrin, K. (2012). Index insurance for developing countries. *Applied Economic Perspectives and Policy, 34*(3), 391-427.

Mohammed, M. A. & Ortmann, G. F. (2005). Factors influencing adoption of livestock insurance by commercial dairy farmers in three Zobatat of Eritrea. *Agrekon 44*(2): 172-186

Morduch, J. (2006). Micro-insurance: The next revolution? In Banerjee, A., Benabou, R. & Mookherjee, D. (Eds.). *What Have We Learned About Poverty?* Oxford University Press.

Olagunju, F. I. & Salimonu, K. K. (2010). Effect of adoption pattern of fertilizer technology on small scale farmers' productivity in Boluwaduro Local Government. *World Rural Observations 2* (3): 23-33.

Ragasa, C., Dankyi, A., Acheampong, P., Wiredu, A. N., Chapoto, A., Asamoah, M. & Tripp, R. (2013). *Patterns of adoption of improved maize technologies in Ghana*. GSSP Working Paper No.34. IFPRI, Accra .

Rosenbaum, P. R. & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika 70*(1): 41-55. http://dx.doi.org/10.1093/biomet/70.1.41

Sauer, J. & Tchale, H. (2009). The Economics of soil fertility management in Malawi. *Review of Agricultural Economics 31* (3): 535-560.

Spiertz, J. H. J. (2010). Nitrogen, sustainable agriculture and food security. A review. *Agronomy for Sustainable Development 30* (1): 43-55

The World Bank. (2015). *Fertilizer consumption (kilograms per hectare of arable land).* Retrieved from http://data.worldbank.org/indicator/AG.CON.FERT.ZS (accessed July 20 2016).

Wiredu, A. N., Zeller, M. & Diagne, A. (2015). What determines adoption of fertilizers among rice-producing households in Northern Ghana? *Quarterly Journal of International Agriculture 54*(3): 263-283