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PROBIT MODEL ANALYSIS OF SMALLHOLDER'S FARMERS DECISION TO USE AGROCHEMICAL INPUTS IN GWAGWALADA AND KUJE AREA COUNCILS OF FEDERAL CAPITAL TERRITORY, ABUJA, NIGERIA

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Abstract

This study examined Probit model analysis of smallholder's farmers decision to use agrochemical inputs in Gwagwalada and Kuje Area Councils of Federal Capital Territory, Abuja, Nigeria. Primary data were used for this study. Data were obtained using structured questionnaire. The questionnaires were administered to sixty smallholder's farmers sampled using a two-stage sampling technique. Data obtained were analyzed using descriptive statistics and Probit model. Eight estimators, age; farm-size; education–level; extension services; access to credit; off-farm income; experiences in farming; in the Probit model were found statistically significant. Results show that the probability of using agrochemical inputs increases with age; farm-size; family-size; education-level; extension services; experiences in farming but decreases where they have off-farm income and access to credits. Mc Fadden Pseudo-R^2 gives 0.6866 and Probit model correctly classified 93%. This study concluded that capacity of agricultural extension agents needs to be improved in the study area to educate farmers to invest in agrochemicals and improved agricultural technologies. Also, Government needs to improve on good road networks and appropriate policies to regulate standard, use, safety needs and environment of use of agrochemicals in the study area.

Keywords: *Agrochemicals, smallholders farmers, probit model, Abuja, Nigeria.*

1. Introduction

Agrochemical a contraction of agricultural chemical is a generic term for the various chemical products used in agriculture. In most cases, agrochemical refers to the broad range of pesticide including insecticides, herbicides, and fungicides. It may also include synthetic fertilizers, hormones and other chemical growth agents and concentrated stores of raw animal manure (Larry, 2012). Most agrochemicals are toxic and can pose danger to human health (WHO, 2008); hence, their use is highly regulated internationally, nationally and regionally with regulations and conventions (PAR, 2000; FAO/WHO, 2001). The cultivation of crops is accompanied by the application of agrochemicals. Farmers are increasingly relying on inorganic agriculture mainly because the soils are poor, and indigenous crop varieties have almost been replaced by improved high yielding varieties which are heavy nutrient miners. Most of the crops cultivated are short duration crops, the crops are also quite susceptible to many insect species, which may not only feed but also reproduce on them. So the farmer seems to have no choice but to treat crops and protect them against insect species and diseases using agrochemicals (Larry, 2012). Agrochemicals are crop protection products or agents used to control plants or weeds, diseases, insects or animals that are undesirable or harmful to man, and or also to promote the growth and development of crops. Local farmers in developing countries have little or no knowledge on how, what, when and how often to apply agrochemicals on their crops; the consequence of which is the destruction of entire crops fields, polluting water bodies and putting human health and environment at risk (Machipisa, 1996; Ntow, 2004; IUPAC, 2008) . Incidentally, many farmers who use these agrochemicals do not know much about the dangers associated with them and hence end up tasting to determine their potency and also failing to protect themselves during their formulation and application. As a result of continuous application of agrochemicals, the fertility status of farm lands is getting worse year after year; many insects and their predators are destroyed and others have evolved resistant strains (Tanzubil, 1997). It is also worth noting that, despite the incessant use of agrochemical products by farmers, 20 – 40 % of potential food production is still lost every year to pests and diseases (Obeng-Ofori, 1998). From an agricultural industry perspective, pesticides are an important component of economic and effective pest control and their continued use is essential (Kent, 1991). Pesticides are widely used in agricultural production to protect crops and animals from pest including insects, mites, birds, ticks, nematodes, weeds, fungus, and other organisms that causes losses and maintain high product quality. Some pesticides are prepared locally by farmers (natural pesticides e.g. neem extract, wood ash) while others manufactured in industries through advanced procedures (synthetic or artificial pesticides). The FAO and WHO statement said that the problem of poor quality pesticides is particularly widespread in sub- Saharan Africa, where quality control is weak. Smallholder farmers is used more generally to describe rural producers predominantly in developing countries, who farm using mainly family labour and for whom the farm provides the principal sources of income (Ellis, 1998). FAO study defines smallholders as farmers with limited resources endowments relatives to other farmers in the sectors (Dixon *et al*, 2003). The World Bank's rural development strategy defines smallholders as those with a low asset base, operating less than 2 hectares of crop land (World Bank, 2003). This study intends to provide answers to the following research questions:

- What are the socio- economic characteristics of sampled smallholder's farmers in the study area?
- What are the factors influencing smallholder's farmers decision to use agrochemical inputs in the study area?

This study seeks to provide answers to the following specific objectives:

- identify the socio-economic characteristics of sampled smallholder's farmers in the study area.
- evaluate factors influencing smallholder's farmers' decision to use agrochemical inputs in the study area.

2. Methodology

2.1. The Study Area

The study was conducted in Gwagwalada and Kuje Area Councils of Federal Capital Territory, Abuja, Nigeria. Federal Capital Territory is located within Latitudes 70^0 $20^|$ North of Equator and Longitudes 60^0 $45^|$ and 70^0 $39^|$. Federal Capital Territory has total land area of about 8,000 Sq Kilometers. It is predominantly a grassy savannah region, thus has potentials to produce both root crops and tubers such as yam and cassava. It also sustains legumes (groundnut & cowpea); grains (maize, sorghum & rice); seeds and nuts (melon seeds & benniseed); animal products (goats, cattle & sheep); fruits and vegetable. Gwagwalada is geographically located at Latitudes 8^0 $56^|$ $59^{||}$ North of Equator and Longitudes $7^0 5^| 59^{||}$ East of prime meridian on the map of the World. Gwagwalada has an area of 1,043 Km^2 and a population of 1,571,770 people and Kuje has an area of 1,644 Km^2 and a population of 97,367 people (NPC, 2006). The people are predominantly farmers.

2.2. Method of Data Collection, Sampling Technique and Sample Size

A structured questionnaire was used to interview the selected farmers. Primary data from the structured questionnaire were therefore summarized and analyzed. A two-stage sampling technique was used. Purposive sampling technique was used to select the two area councils (Gwagwalada & Kuje) because the people are predominantly farmers; a simple random sampling technique was used to select sixty (60) farmers from the two area councils.

2.3. Method of Data Analysis

Data analysis methods used were descriptive statistics and Probit model. Descriptive statistics were used as a preliminary investigation procedure to gain an understanding of inherent significant socio-economic characteristics of the smallholder farmers.

The Probit model represents another type of widely used statistical model for studying data with binomial distributions. The Probit model can be expressed in probability thus:-

$$Prob(Y = 1) = 1 - F[-\sum_{K=1}^{K} \beta_K b_K] = F[\sum_{K=1}^{K} \beta_K b_k] = \varphi[\sum_{K=1}^{K} \beta_K b_K] \qquad (1)$$

The equation for probability of non event is then:-

$$Prob(Y = 0) = 1 - \varphi[\sum_{K=1}^{K} \beta_K b_K] \qquad (2)$$

The farmer's decision on use of a particular input depends on the criterion function:-

$$Y^* = \gamma Z_i + U_i \qquad (3)$$

Where,
Y^* =Underlying index reflecting the difference between the use of an input and its non-use.
γ = Vector of Parameters to be estimated
Z_i = Vector of Exogenous Variables which explain Use of an Input
U_i = Standard Normally Distributed Error Term

Given the farmers' assessment, which ${Y_i}^*$ crosses the threshold value, 0, we observe the farmer using the input in question. In practice, ${Y_i}^*$is unobservable. Its counterpart is $Y_{i,}$ which is defined by;-

$Y_i = 1$ If ${Y_i}^* > 0$ (Farmer I use the input in question), and
$Y_i = 0$ If otherwise

In the case of normal distribution function, the model to estimate the probability of observing a farmer using an input can be stated as :-

$$P\left(Y_i = \tfrac{1}{X}\right) = \varphi(X\beta) = \int_{-\alpha}^{X\beta} \tfrac{1}{\sqrt{2\Pi}} exp\left(\tfrac{-Z^2}{2}\right)dz \quad (4)$$

Where,
P = Probability that the ith farmer use the input and 0 otherwise
X $= K$ by 1 Vector of the explanatory Variables.
Z = Standard Normal Variable (i.e $Z \sim N(0, \delta^2)$ and
β $= K$ by 1 Vector of the Coefficients estimated.

For a non-dichotomous variable, the marginal probability is defined by the partial derivative of the probability that $Y_i = 1$ with respect to that variable. For the jth explanatory variable, the marginal probability is defined by:-

$$\frac{\partial P}{\partial X_{ij}} = \varphi(X_i\beta)\beta_j \quad (5)$$

Where,
$\varphi(.)$ = Distribution Function for the Standard Normal Random Variable
β_j = Coefficient of jth explanatory Variable.

The Probit model specification in this analysis can be written as:-

$${Y_i}^* = X_i\beta + \varepsilon_i \quad (6)$$

$$Y_i = \begin{cases} 1 \; if \; {Y_i}^* \geq 0 \\ 0 \; if \; {Y_i}^* < 0 \end{cases}$$

Where,
Y_i = Observed Dichotomous Dependent Variable which takes Value 1 when the ith Smallholder Farmer use agrochemical inputs and 0, otherwise.
${Y_i}^*$ = Underlying Latent Variable that indexes the use of agrochemicals.
X_i = Row Vector of Values of K Regressors for the ith Smallholder Farmers.
$\beta = K \times 1$ Vector of Parameters to be estimated
ε_i = Error term which is assumed to have standard Normal Distribution.

3. Results and Discussion

3.1. Descriptive Statistics of Sampled Smallholder Farmers and Apriori Expectations

Table 1 show the variables used in Probit model and the apriori expectation. The mean age of sampled smallholder's farmers in the study area is 43 years (Table 2) and this has implications on the availability of family labour and their productivity because age has a direct bearing on the availability of farm labour and the ease with which improved agricultural practices are adopted (Rauf,2010). Age is a very important factor that can have serious effect on decision making. At times, it could have negative or positive effects (Table 1). In the rural areas where most people are illiterate, age at times could have negative effect since old people that are already used to a particular way of doing things especially farmers that are already used to old ways may not be interested in improved technologies. The average years of schooling is 13. This implies that smallholder's farmers had post primary education. Educated farmers are more aware of the benefits of using agrochemicals or because they are better able to afford to purchase agrochemicals. In some cases, among the educated individuals, with age, farmers tend to be more enlightened and hence able to understand innovation quickly and consequently adopt it. From Table 2 it was found that all the smallholder's Farmers sampled were very experienced in farming. Sampled farmers had an average of 10 years experience in farming. Experience in itself could contribute positively or negatively to technology adoption (Table 1), while at times farmers that are already used to doing things in a particular old way may find it difficult to change and as such experience could become an impediment to adoption of innovation. However, experience can also contribute positively since farmers that have seen and experienced the advantages of such innovations can share their experiences thereby encouraging other farmers to adopt. Table 2 indicated that on the average, the farm size cultivated by each farmer is 1.12 hectares and much more family labour was than hired labour. One of the probable reasons for hiring less proportionate units of labour could be the fact that the average age of farmers are within the active age bracket as revealed in Table 2 and in addition large family size could provide the needed assistance for farm operations.

Table 1. Variables Used in Probit Model and Expected Signs (Apriori Expectations)

Variable	Unit of Measurement	Expected Signs
Age	Years	(±)
Farm Size	Hectares	(+)
Family Size	Number Per Household	(+)
Educational Level	Years	(+)
Extension Services	Dummy (1,Yes; 0,Otherwise)	(+)
Access to Credit	Dummy (1,Yes; 0,Otherwise)	(±)
Off-Farm Income	Naira	(+)
Experiences in Farming	Years	(±)

Source: Field Survey, 2012

Table 2. Descriptive Statistics of Sampled Smallholder Farmers

Variable	Average
Farm Size (Hectares)	1.12
Age (Years)	43
Family Size (Number Per Household)	6
Educational Level (Years)	13
Experience in Farming (Years)	10

Source: Field Survey, 2012

3.2. Maximum Likelihood Estimates and Marginal Probabilities for the Explanatory Variables in the Probit Model

Table 3 show that extension services was significant ($P < 0.01$).It is acknowledged that farmers are likely to be influenced to make adoption decisions by information sources which they consider most important since such sources are associated with reliability and credibility (Rogers, 2003). The result show the important role played by extension agents as sources of information that influence adoption of agrochemicals. This indicates that farmers still trust the government extension services when it comes to delivery of agricultural information. It is not only important to avail farmers with the information about a new innovation, but also the method of delivering this information is critical in determining adoption. As extension services increases, tendency for smallholder's farmers to use agrochemicals increases. This is the expected results of the extension services (Table 1).According to marginal effects, for an extension service with large size, the probability of using agrochemicals by smallholder's farmers increases by 59.6%.Family size is used as a proxy for labour availability and has a positive effect on smallholder's farmers to adopt agrochemicals. The coefficient is statistically significant at the 1% level in the Probit model. These findings confirm that labour availability has an impact on the decision for smallholder's farmers to adopt and intensify agrochemicals use. These results are consistent with those reported by Zegeye *et al* (2001) for adoption of improved maize technology indicating that labour availability increases the rate of technology adoption. The results in Table 3 indicate that a unit increase in household size raises the probability of agrochemicals use among smallholder's farmers by 16.7%. The coefficient for education level has the expected positive sign and is statistically significant at 10% level for the agrochemicals adoption case. This result supports the hypothesis that human capital plays a positive role in the acquisition and evaluation of new ideas. Moreover programs and materials promoting technological change typically favor literate farmers. This result is consistent with other findings in Africa including (Nkamleu & Adesina 2000; Bacha *et al*, 2001; Zegeye *et al*, 2001; Chirwa, 2005; Chianu & Tsiyii, 2004). Off- farm income is hypothesized to compensate for any additional financial resources that are associated with new technologies. The coefficient for off-farm income has a negative effect for the adoption of agrochemicals by smallholder's farmers. The parameter is statistically significant at 10% level of the Probit model. For the intensity of use, the coefficient is negative. Results are contrary to what is reported by Chirwa (2005) but support findings by Makokha *et al* (2001).This negative effect could be attributed to the higher relative returns from other investments. If off-farm enterprises have higher returns, then smallholder's farmers might prefer to invest in options that have better returns, given the risk involved in agriculture. Availability of off-farm income decreases the likelihood of adopting and intensifying agrochemicals use among non-adopters by 3.6%. In this study, farm size in hectares is taken as a proxy for wealth. The coefficient for farm size is positive as expected (Table 3 and Table 1). The coefficient is statistically significant at the 10% level for the Probit model used. A unit increase in farm size increases the probability of agrochemical adoption for non- adopters by 5.5%. This finding is consistent with other studies carried out on adoption of agricultural technologies (Zegeye *at al*, 2001; Knepper, 2002; Isham, 2002; Chirwa, 2005).These results are contrary to what Croppenstedt and Demeke (1996) found on adoption of chemical fertilizer. The findings support the notion that farm size influences agrochemicals adoption and intensify of use, which is compatible with the notion that access to agricultural inputs and other services is easier for larger producers. Access to credit has a negative association with use of agrochemicals by smallholder's farmers. This is consistent with expected sign (Table 3 and Table 1). This finding suggests that farmers use credit to engage in non-farm activities, which are likely to have returns than agricultural production and as a result it shows that access to credit is not a binding constraint to agrochemical input use by smallholder's farmers. As presented and explained in Table 3 results estimated from Probit model, the model has been estimated by the maximum likelihood method. The model is significant at 1% level of probability. The estimated coefficients and standard errors revealed which factors influence respondent's decision to use agrochemical inputs by smallholder farmers. A statistically significant coefficient suggests that the likelihood of decision to use agrochemical inputs by smallholders' farmers will increase/decrease as the response of the explanatory variable increases/decreases. The likelihood ratio test statistic results of the model indicate that all variables are statistically significant. McFadden's Pseudo-R^2 was calculated, and obtained values indicate that the independent variables included in the Probit model explain significant proportion of the variations smallholder's farmers decision to use agrochemical inputs. It was calculated about 0.6866.This value represents that variables placed in the model explain high level of the probabilities of decision to use agrochemical inputs by smallholder inputs. Correct prediction rate obtained from Probit model is 93%.This meant that the Probit model predicts 93% of the cases correctly.

Table 3. Maximum Likelihood Estimates and Marginal Probability for the Explanatory Variables in the Probit Model.

Variable	Estimates	t-Ratio	Marginal Probabilities
Age	0.0202**	2.51	0.018
Farm -Size	0.026*	1.87	0.055
Family-Size	0.024**	2.84	0.167
Educational Level	0.232*	1.76	0.027
Extension Services	0.408***	3.13	0.595
Access to Credit	-0.021***	2.83	-0.022
Off-Farm Income	-0.237*	1.77	-0.036
Experience in Farming	0.0259***	3.121	0.010
Log-Likelihood	-55.924		
Restricted Log-L	-179.742		
Mc-Fadden Pseudo-R^2	0.6866		
Predicted Percentage Correction	93.0		
Significance Level	0.00000		

Source: Field Survey, 2012

***- Significant at 1% Probability Level

**- Significant at 5% Probability Level

*- Significant at 10% Probability Level

4. Conclusion

This study in conclusion describes some factors involved in adoption of agrochemicals, specifically those that influence the adoption and intensity of use of agrochemicals among smallholder's farmers in the study area. This study concluded that decision to use agrochemical inputs depends on age; farm size; family size; education level; extension services; access to credit; off-farm income; experience in farming. The role of information in farming cannot be overemphasized. Agricultural information reaches the targeted smallholder's farmers. The smallholder's farmers in the study area accessed information from government extension agents, print media, and other farmers. The implications for this conclusion is that since farmers seemed to still trust the information from the government, efforts should be made to avail this information preferably through print media such as farmers magazines and newspapers which could probably be distributed periodically to farmers as reference materials. Good road networks to near and distant farms should be topmost in the list of government priorities to ensure accessibility to these inputs and their use. In the light of this conclusion, the necessary policies are needed to regulate standard, use, safety needs and environment, adequate price of agrochemicals and a mechanism to reach smallholder's farmers through extension agents.

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