AN APPLICATION OF PROBIT ANALYSIS TO FACTORS AFFECTING SMALL HOLDER FARMER'S DECISIONS TO USE FERTILIZER IN OHAJI/EGBEMA AREA OF IMO STATE, NIGERIA

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ABSTRACT

This study analyzed factors affecting smallholder farmers' decisions to use fertilizer in Ohaji/Egbema area of Imo State, Nigeria. Primary data were obtained between April and June 2015 with structured questionnaire from 202 randomly selected smallholder farmers. Data obtained were analyzed using descriptive statistics and probit model. Factors affecting smallholder farmers' decisions to use fertilizers were farm size, education level, extension contact, net farm income, farming experience, cost of fertilizer, and perceived soil fertility status. Mc-Fadden's Pseudo-R^2 value of 0.6879 indicates that the independent variables included in the probit model explain 69% significant proportion of the variations in smallholder farmers' decisions to use fertilizer.
The pobit model predicted 82% of the factors affecting fertilizer use by smallholder farmers. The role of extension service in improved technology use cannot be over emphasized. The distribution of fertilizers to farmers through the GSM services should be restored since it proved an effective mechanism to reach smallholder farmers in input supply and distribution.

Keywords: *Fertilizer, smallholder farmers, probit model, Ohaji/Egbema, Imo State, Nigeria.*

INTRODUCTION

Agriculture plays a significant role for many countries of Africa. Indeed, the importance of agriculture to the growth of the Nigerian economy cannot be overemphasized in relation to the labour force it attracts (Oluwatayo, 2009; Oruonye, 2011). Agriculture in Nigeria is predominantly on a smallholder basis. About 83% of farm holdings are less than two hectares in size, although there are some large farms and plantations, particularly for oil palm, rubber, cocoa, and coconut, and to a lesser extent cassava, yam, cocoyam, maize, rice, pineapple, plantains, banana and vegetables (Oseni, 2014;Ahmadu and Egbodion (2013).

The smallholder farmers are dispersed, and this makes provision of support services expensive and ineffective (Chukwuji, 2008). Crops production is also largely rain-fed with limited mechanization and inadequate use of high and stable yielding crop varieties, good agricultural practices, fertilizers, and other agro-inputs (Edward et al, 2014; Osondu and Obike, 2015). These among other things have contributed to the observed low levels of productivity in the agricultural sector (Chamberlin, 2007; Abang and Agom, 2004).

Fertilizer is regarded as crucial for crop production by smallholder farmers. Intensive use of small holder farmers. Intensive use of chemical fertilizer (henceforth, fertilizer) in conjunction with improved seed varieties have brought about increased food production in Nigeria. However, increased fertilizer use has not come without costs to society. Empirical studies have shown that on many high-yielding farmlands, the nitrogen fertilizer application rate has been too high, resulting not only in decreased efficiency and large costs; but also negative impacts on air and water quality (Zhu and Chen, 2002; Wang *et al*, 2005; Yuan *et al*, 2010). How best to influence farmers' fertilizer use to improve crops productivity without compromising their welfare and development opportunities is an important question to be investigated. The motivation of this study is to understand the factors determining farmer's fertilizer use for formulating effective intervention strategies. In the existing literature, the analysis of the decision on fertilizer use has mainly considered the factors lying within the public domain (e.g, prices and marketing, fertilizer provision and distribution, research and credit, etc), and on agro-climatic conditions and characteristics of the farm or the farmer (e.g, education, age, experience and farm resources). Most earlier studies on fertilizer use by economists focused on fertilizer adoption and assume that farmers make adoption decisions based on utility maximization.

However, social scientists have argued that farmers' subjective assessments of agricultural technologies are also important in influencing their adoption behaviour in several regions of (Abdoulaye and Sanders, 2005; Adesina and Baidu-Forson, 1995; Adesina and Zinnah, 1993; Yuan, 2010). Gwen that majority of farmers in Imo State use fertilizer and adoption is not a problem, this paper intends to investigate the factors determining the farmers' decisions about whether or not to use fertilizer in food crop production, considering the negative impacts on farmland and the environment.

METHODOLOGY

The study was undertaken in the Ohaji/Egbema area of Imo State which is one of the 27 Local Government Areas (LGAs) of the state. The LGA lies between latitudes 5^0 56' N and 7^0 06' N and longitudes 6^0 53' E and 7^0 45'E. Farming is the dominant occupation of the people, and the major crops produced include; cassava, maize, vegetables, yam, plantains and pineapples. Farmers level of use of fertilizer in the area to improve crops yield has reduced due to observed detrimental impacts of fertilizer use on the farmlands and environment.

The sampling frame used for the study was the list of 403 registered cassava – based smallholder farmers in the LGA which was obtained from the Imo State Agricultural Development Programme (ADP) at the time of this study. From this sampling frame a sample size of 202 farmers was determined using the sample size model by Yamane (1967) specified as;

$$n = \frac{N}{1+N\,(e^{z})} \quad - \quad - \quad - \quad (1)$$

where, n=sample size for the study, N=total sampling frame, and e = tolerable error level of 0.05. Simple random sampling was applied to the sampling frame to select the sample size of 202 cassava-based farmers for the study.

A structured questionnaire was used t collect information on farmers' socioeconomic and farm level characteristics that were considered to be affecting the smallholder farmers' decision on whether or not to use fertilizer. The researchers were assisted in the process of data collection by trained enumerators. Data collection using cost route approach took place between April and June, 2015.

Analytical Techniques

Descriptive Statistics (percentage and mean) were used to examine the socioeconomic and farm level characteristics of the farmers, while inferential statistics (probit model) was used to determine factors affecting smallholder farmers decisions to use fertilizer. According to Nagler (2002), probit model constrains the estimated probabilities to be between o and 1 and relaxes the constraint that the effect of the independent variable is constant across different predicted values of the dependent variable. The probit model assumes that while we only observe the values of o and 1 for the variable Y, there is a latent, unobserved continuous variable y* that determines the value of y. The other advantages of the probit model include believable error term distribution as well as realistic probabilities (Nagler, 1994)

Thus, for this study the probit model is preferred and used. The farmer's decision on use of a particular input depends on the criterion function;

$Y^{*}=Yz_i + u_i$ - - - (2)

where,

Y^*= underlying index reflecting the difference between the use of an input and its non-use.

Y= vector of parameter to be estimated

Zi=vector of exogenous variables which explain use of an input

Ui=standard normally distributed error term.

Given the farmers' assessment, which Y_i crosses the threshold value, o, we observe the farmer using the input in question. In practice, Y_i is unobservable. Its counterpart is Yi, which is defined by;

$Y_i=1$ if $Y_i.>0$ (farmer 1 use the input in question), and

Y_i=O 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;

$$P\,(Yi=1/x) = \phi\,(XB) = \int_{-a}^{XB} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-z^2}{z}\right) dz \qquad - \quad - \quad (3)$$

where,

P= probability that the ith farmer use the input and o if otherwise

X= k by 1 vector of the explanatory variables

Z= standard normal variable (i.e z 2N (O, $o\text{-}^2$) and

B= 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;

$$\frac{dp}{dxy} = \phi\,(X_i^B)B_j$$

Where,

ϕ (.) = Distribution function for the standard normal random variable

B_j= coefficient of $_j$th explanatory variable

The probit model specification in this analysis can be written as,

$Y_i=X_i^B + \Sigma_i$ - - - (4)

Y_i = o if Y_i* <o, I if Y_i* $\leq$O

where,

Y_i =	Observed Dichotomous Dependent variable which takes value I when the ith smallholder farmer use fertilizer and o, otherwise,
Y_i =	Underlying latent variable that indexes the use of fertilizer,
X_i=	Row vector of values of k Regressors for the ith smallholder farmers,
B=	kx1 vector of parameters to be estimated
Σ_i=	Error term which is assumed to have standard Normal Distribution.

Table 1 shows the variables used in probit model and the apriori expectations.

Table 1. Variables used in probit model and expected signs (apriori expectations)

Variable	Unit of measurement which takes the value of I if the farmer used fertilizer, and o if otherwise	Expected sign
Smallholder farmers' decision to use fertilizer (dependent variable, Y_i)		
Farm size (X_i)	Hectares	(+)
Farmer's age (X_2)	years	(+)
Education level (X_3)	years	(+)
Extension contact (X_4)	number of visits by agricultural extension officer in the previous year	(+)
Access to credit (X_5)	Dummy (1, if yes, o otherwise)	(+)
Farm income (X_6)	Naira	(+)
Household size (X_7)	Number of persons	(+)
Farming experience (X_8)	Years	(+)
Membership of farmers' Associations (X_9)	Dummy (1 if a farmer is member, o if otherwise	(+)
Distance from fertilizer market (X_{10})	Km	(-)
Cost of fertilizer (X_{11})	Naira	(-)
Perceived soil Fertility states (X_{12})	Dummy (1 if a farmer perceived the soil to be fertile, o if otherwise	(-)

RESULTS AND DISCUSSION

Socioeconomic and farm level characteristics of small holder farmers

Table 2 shows the average characteristics of smallholder farmers.

The mean age of the farmers was 42 years, while the mean farmsize, farming experience, education level, and household size were 1.03 hectares, 11 years, 7 years, and 8 persons respectively. Also, the mean extension contact, net farm income, distance from fertilizer market, and cost of fertilizer were 0.63 visit per annum, ₦183609, 3.08km and ₦10503 per 50kg bag respectively.

Table 2. Average characteristics of smallholder farmers

Variable	Average	Standard duration
Farm size (Hectares)	1.03	0.64
Age (Years)	42	10
Farming experience (years)	11	4
Education level (years)	7	2
Household size (Number of persons)	8	3
Extension contact (Number of visits)	0.63	0.29
Net farm income (Naira/per hectare	183,609	613
Distance from fertilizer market (km)	3.08	1.06
Cost of fertilizer (Naira)	10,503	201

Source: Survey Data, 2015

Maximum likelihood Estimates and marginal probabilities for the explanatory variables in the probit model

Table 3 shows the maximum likelihood estimates and marginal probabilities for the Explanatory variables in the probit model. The table shows that the coefficient of farm size (X_1) is positive as expected and statistically significant at the 1% level for the probit model used. A unit increase in farmsize increases the probability of fertilizer use by 4.5%.

This finding is consistent with other studies carried out on fertilizer use and adoption (Zegeye *et al.*, 2001; Knepper, 2002; Isham, 2002; Chirwa, 2005; Omotayo *et al*., 2012).

The coefficient for education level (X_3) has the expected positive sign and is statistically significant at 1% level. Education gives farmers better access to information about the fertilizer and more knowledge of how much fertilizer to use. Thus, education

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

Explanatory variable	Coefficients	t-ratio	marginal probabilities
Farmsize (X_1)	0.069	3.372**	0.045
Farmer's age (X_2)	0.053	1.516	0.017
Education level (X_3)	0.092	3.175**	0.025
Extension contact (X_4)	0.027	3.884**	0.547
Access to credit (X_5)	-0.022	-1.418	-0.021
Net farm income (X_6)	0.317	3.116**	0.039
Household size (X_7)	-0.132	-1.552	-0.033
Farming experience (X_8)	0.278	3.093**	0.013
Membership of farmers' associations (X_9)	0.031	1.839	0.112
Distance from fertilizer market (X_{10})	0.106	1.921	0.103
Cost of fertilizer (X_{11})	-0.439	-3.008**	-0.027
Perceived soil Fertility status (X_{12})	-0.037	-2.518*	-0.018
Log-likelihood	-55.916		
Restricted log-L	-179.742		
Mc-Fadden Pseudo-R^2	0.6879		
Model chi-square (χ^2)	39.037		
Predicted percentage Correlation	82.00		
Significance level	0.00000		

** Significant at 1% probability level

*Significant at 5% probability level

Source: Survey Data, 2015

is expected to favourably affect fertilizer use decisions. This result is consistent with earlier findings by Nkamleu and Adesina (2000), Bacha *et al* (2001), Zegeye *et al* (2001), Chirwa (2005), Chianu and Tsiyii (2004), Omotayo *et al* (2012), and Yuan *et al* (2010).

The coefficient of extension contact (X_4) was positive as expected and statistically significant at 1% level. This implies that, as extension service increases, tendency for smallholder farmers to use fertilizer increases. According to marginal effects if, extension contact increases, the probability of using fertilizer by smallholder farmers increases by 54.7%.

The coefficient of net farm income (X_6) is positive as expected and statistically significant at 1% level, implying that increases in the net farm income earned by smallholder farmers lead to increases in fertilizer use. Marginal effects result shows that if the net farm income increases by ₦1.00, the probability of farmers' use of fertilizer increases the 3.9%.

The coefficient of farming experience (X_8) is positive as expected and statistically significant at 1% level. This implies that farmers that acquired more experience had the probability to use fertilizer more than the new entrants into farming, and this is supported by the marginal effect of 1.3% increase in probability of fertilizer use for any one year increase in farming experience.
The coefficient of cost of fertilizer (X_{11}) is negative as expected and statistically significant at 1% level, which implies that increase in cost of fertilizer lead to reduction in fertilizer use by the smallholder farmers. The result of marginal effects indicate that a ₦1.00 increase in cost of fertilizer leads to 2.7% reduction in the probability of smallholder farmer's use of fertilizer. There significant variables are the important factors affecting smallholder farmers' decisions to use fertilizer in the study area.

The coefficient of perceived soil fertility status (X_{12}) is negative as expected and statistically significant at 5%. This implies that if farmers perceive the soil to be fertile, they do not use fertilizer. Marginal effects result indicates that smallholder farmers have tendency of 1.8% reduction in fertilizer use where soil fertility status of farmland is perceived to be fertile.

The coefficients of farmer's age (X_2), access to credit (X_5) household size (X_7), membership of farmers associations (X_9), and distance from fertilizer market (X_{10}) were not statistically significant at 5% level of probability.

Thus, these variables are not factors affecting smallholder farmers' decisions to use fertilizer in the study area. Table 3 also shows that the estimated probit model is significant at 1% level of probability. The estimated coefficients and standard errors showed the factors that influence smallholder farmers' decisions to use fertilizer. A statistically significant coefficient suggests that the likelihood of decision to use fertilizer by smallholder farmers will increase/decrease as the response of the explanatory variable increases/decreases. The likelihood ratio test statistic results of the model indicate that six variables are statistically significant at 1% level while one variable is significant at 5% level of probability. Mc-Fadden's Pseudo-R^2 was calculated as 0.6879 which indicates that the independent variables included in the probit model explain 69% significant proportion of the variations in smallholder farmers' decisions to use fertilizer. This value also presents that variables placed in the probit model explain high level of the probabilities of decision to use fertilizer by smallholder farmers. Correct prediction rate obtained from probit model was 82%, which means that the model predicts 82% of the fertilizer use factors correctly.

CONCLUSION AND RECOMMENDATIONS

This study concludes that smallholders' decisions to use fertilizer depends on farm size, education level, extension contact; net farm income, farming experience, cost of fertilizer, and perceived soil fertility status. The role of extension service in improved technology use was highly significant, and cannot be over emphasized.

Since farmers appeared to still trust the information from the extension service, efforts should be made to provide this information preferably through mass media such as radio and television, and print media such as extension magazines and news letters which could probably be distributed periodically to farmers as reference materials. Fertilizers should be made readily available to the farmers at affordable prices. The distribution of fertilizers to farmers through the GSM services should be restored since it proved effective mechanism to reach smallholder farmers in input supply and distribution.

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