Socio-Economic Determinants of Intensity of Adoption of Cocoa Research Innovations in Ghana

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Abstract
A number of technologies expected to increase cocoa yield per hectare have been introduced by the Cocoa Research Institute of Ghana (CRIG) but cocoa farmers are reluctant to adopt and intensify the use of these technologies. This study therefore sought to identify the factors which influence intensity of adoption of cocoa research innovations in Ghana. Six hundred (600) cocoa farmers selected through multistage sampling technique were used for the study. The instrument used for data collection was a questionnaire. The double hurdle model was used to estimate the determinants of intensity of adoption and factors which were found to be statistically significant were age of the farmer, household size, farm size, education, hired labour, own labour, non-hired labour, membership of association and frequency of extension advice. It is therefore recommended that government should improve upon facilities in the rural areas to reduce the migration of the youth to the urban centres. Land acquisition should be eased to enable farmers increase the sizes of their farms and encourage new farmers also enter the cocoa industry. Also farmers should be given training through non-formal education and encouraged to join producer associations. Finally, COCOBOD should continue to provide extension service.
Keywords: Socio-economic, intensity, adoption, cocoa research, innovation

1.0 INTRODUCTION

Cocoa is very important to the economy of Ghana. The industry consists of small holder farmers who produce cocoa beans, licensed cocoa buying companies (LBCs) which purchase the cocoa beans, quality assurance by the Quality Control Company (QCC), a subsidiary of Ghana Cocoa Board (COCOBOD) and private hauliers which haul the cocoa beans to take-over points. Also involved in the industry are providers of warehousing services and other logistics and Cocoa Marketing Company (CMC), a division of COCOBOD which is responsible for export of the cocoa beans (Awua, 2002).

According to the Ghana Statistical Service (2014) about 794,129 households are involved in cocoa production. The export of cocoa contributed about 32 per cent of the total export earnings in 2013 (ISSER 2014). The cocoa tree cover protects the environment and it has been identified to have medicinal value. Also, the cocoa sector contributes to educational development of the country as COCOBOD grants scholarships to brilliant children of cocoa farmers in senior high schools. In addition to these contributions, there have been a number of infrastructural developments such as provision of roads in the cocoa growing areas and hospitals from revenue obtained from the cocoa sector.

In order to increase cocoa output, the Cocoa Research Institute of Ghana (CRIG) has introduced a number of innovations or practices which farmers have to follow to obtain required yield. These practices include proper maintenance of the farm by weeding at least twice in a year, pruning semi parasitic mistletoe plant from the cocoa trees and cutting down cocoa trees affected by swollen shoot virus disease. Also, to improve soil fertility, the farmer has to apply fertilizer in prescribed quantities. The farmer has to spray fungicides in right quantities to control black pod disease and spray insecticides to control insects such as black ants, stem borers, mealy bugs, termites and red ants. Ripe cocoa should be harvested; fermentation should be between six and seven days before they are dried. The cocoa should be properly dried before they are put in sacks for sale (CRIG, 2010).

Despite the potential increase in yield through the adoption of innovations or technologies introduced by CRIG, many cocoa farmers are not adopting the technologies. It is therefore important to ascertain the factors which influence the intensity of adoption of cocoa research innovations in Ghana.

2.0 OBJECTIVES OF THE STUDY

The objectives of the study are:

1. to determine the factors influencing intensity of adoption of CRIG recommended cocoa technologies by cocoa farmers, and
2. to make policy recommendations.

The paper is structured as follows: immediately following the introduction and objectives are the review of related literature and methodology for the study. Next are the data analysis, results and discussions. Conclusions and recommendations are provided in the last section of the paper.

3.0 REVIEW OF RELATED LITERATURE

This section of the paper deals with a review of relevant literature. Both theoretical and empirical literatures have been reviewed.

3.1 Theoretical Literature

A number of theories have been propounded to explain technology adoption. These include the theory of reasoned action, theory of planned behaviour, unified theory of acceptance and use of technology, diffusion innovation theory and technology-organisation-environment framework. Others are rational expectation theory of technology adoption and agricultural household models.

Rogers (2003) defines technology as a design for instrumental action that reduces the uncertainty in the cause-effect relationship involved in achieving an outcome. Adoption has also been defined by Feder, Just and Zilberman (1985) as the degree of use of a new technology in a long run equilibrium when a farmer has full information about the new technology and its potential. Feder et al (1985) further explained that adoption at the farm level describes the realization of farmers' decision to apply a new technology in the production process.

Double Hurdle Model

The decision to adopt or not to adopt a technology is a binary one and the event may lead to generation of several zeros for non-adopters. Having taken a decision to adopt a technology, a farmer may intensify its usage. Feder et al (1985) defined intensity of adoption as the level of adoption of a given technology (for instance the number of hectares planted with improved seed or the amount of fertilizer applied per hectare). The adoption and intensity of use decisions can be made jointly or separately. The decision to adopt may precede the decision on the intensity of use and the factors affecting each decision may be different. According to Green (1993) in the case where decision to adopt a technology and how much of it to adopt are not jointly made, it is more suitable to apply a hurdle model.

Cameron and Trivedi (2010) explained a hurdle model as a modified count model in which there are two processes, one generating the zeros and one generating the positive values. The two models are not constrained to be the same. The concept underlying the hurdle model is that a binomial probability model governs the binary outcome of whether a count variable has a zero or a positive value. If the value is positive, the "hurdle is crossed," and the conditional distribution of the positive values is governed by a zero-truncated count model. A hurdle model has the interpretation that it reflects a two-stage decision-making process, each part being a model of one decision. The two parts of the model are functionally independent. Therefore the maximum likelihood (ML) estimation of the hurdle model can be achieved by separately maximizing the two terms in the likelihood, one corresponding to the zeros and the other the positives. The first part uses the full sample, but the second part uses only the positive count observations.

The double hurdle model is designed to analyse instances of an event which may or may not take place and if it takes place, takes on continuous positive values. The double hurdle model was originated by Cragg (1971). In the double hurdle model the adoption decision may be estimated with a probit or logit regression using all observations followed by a truncated regression on the non-zero observations. The non-zero observations may be estimated with a Poisson regression. Teklewold, Dadi and Dana (2006), defined the double hurdle model as a parametric generalization of the Tobit model, in which two separate stochastic processes determine the decision to adopt and the level of adoption. They specified the model as in equation 1.

$$\left.\begin{array}{l} D_i = 1 \text{ if } D_i^* > 0 \text{ and } 0 \text{ if } D_i^* \leq 0 \\ D_i^* = \alpha' Z_i + \mu_i \end{array}\right\} \quad \ldots (1)$$

Where D is adoption, D* is a latent variable that takes the value 1 if the farmer adopts exotic poultry and zero, otherwise. Z is a vector of household characteristics which include age of household head; sex of household head; level of education of the household head; total family size among others.
Teklewold et al (2006) specified the level (or intensity) of adoption (Y) as in equation 2.

$$\left.\begin{array}{l} Y_i = Y_i^* \text{ if } Y_i^* > 0 \text{ and } D_i^* > 0 \\ Y_i = 0 \text{ otherwise} \\ Y_i^* = \beta' X_i + v_i \end{array}\right\} \quad \ldots (2)$$

Where Y_i is the observed answer to the intensity of adoption which in their case was proportion of exotic breed, and X is a vector of individual's characteristics and β is a vector of parameters and v_i error term.
The error terms μ_i and v_i are distributed as follows:

$$\left.\begin{matrix}\mu_i \sim N(0,1) \\ v_i \sim N(0,\sigma^2)\end{matrix}\right\}$$

The log-likelihood function for the double hurdle model was specified by Teklewold et al (2006) as:

$$LogL = \sum_0 \ln\left[1-\Phi\left(\alpha Z_i^{'}\right)\left(\frac{\beta X^{'}_i}{\sigma}\right)\right] \sum_+ \ln\left[\Phi\left(\alpha Z_i^{'}\right)\frac{1}{\sigma}\phi\left(\frac{Y_i-\beta X^{'}_i}{\sigma}\right)\right] \quad \ldots (3)$$

Where Φ and ϕ are the standard normal cumulative distribution function and density function, respectively. The first portion is the log-likelihood for a probit, while the second portion is the log-likelihood for a truncated regression with truncation at zero.

3.2 Empirical Literature Review

Several studies have been conducted on adoption of technologies in the cocoa sector of Ghana. These include Donkor, Henderson and Jones (1991); Boahene (1995); Acquaah (1999); Domon,Huis, Leeuwis, Obeng-Ofori and Sakyi-Dawson (2004); Edwin and Masters (2005); Vigneri (2008); Opoku, Dzene, Caria, Zeitlin and Teal (2009); Aneani, Anchirinah, Asamoah and Owusu-Ansah (2011); Kyei, Foli and Ankoh (2011); Wiredu, Mensah-Bonsu, Andah and Fosu (2011); Aneani, Asamoah, Owusu-Ansah and Asamoah (2012); Dzene (2012) and Asamoah (2015). It is worth noting that these studies did not use the double hurdle model.

Closely related to the hurdle model was a study by Opare (1980), who investigated the extent to which cocoa farmers in Ghana had adopted recommended cocoa practices. He used questionnaire to gather information from 1191 farmers. The extent of a cocoa farmer's adoption practices was defined operationally in terms of the farmer's score using arbitrary defined indices. A numerical value of zero was assigned to non-adoption and one to the adoption of each practice. Respondents were assessed on the following five practices: mistletoe control, capsid control, swollen shoot management, harvesting and fermentation. The analysis showed that on the average farmers had adopted two practices and had correct knowledge of three out of the five selected recommended practices.

The double hurdle model was employed by Teklewold et al (2006) to study the factors that determine the rate and intensity of adoption of poultry technology. The double hurdle model was used because it was possible to segment factors in the adoption process that need to be targeted for improvement.

In their study of household resource endowment and determinants of adoption of drought tolerant maize varieties, Legese, Langyintuo, Mwangi, Jaleta and Revere (2009) used the double hurdle approach. They used data from 369 households in the Adama and Tulu Jido Kombolcha districts in Ethiopia. The households were stratified into poor and well endowed categories based on wealth indices constructed using their productive assets by the principal component method. A double hurdle model similar to that of Teklewold, et al (2006) was then specified and estimated for each wealth group to assess factors influencing adoption and use intensity of improved varieties. The results indicated that factors influencing adoption and use intensity of improved maize varieties among 61% of the poorly endowed households differed from those observed for the well endowed households. The study therefore recommended specific interventions to improve the adoption and use intensity of improved maize varieties among farmers in the two and similar districts of Ethiopia. However, the impact of the technology adoption on output was not examined.

Another study which used the double hurdle model was that of Shiferew, Muricho, Okello, Kebede and Okacho (2010) which dealt with adoption of improved groundnut varieties in Uganda. The study examined the factors affecting the decision to adopt and the intensity of adoption of improved groundnut varieties in Uganda. The multi-hurdle regression analysis was used to identify the specific factors that determine access to information, seed supply and capital constraints and the overall demand for new varieties conditional on overcoming these hurdles. Participation in farmer groups and distance to information centres were critical for accessing variety information. The results indicated that productive assets like bicycles and farm size were related to improved access to information, seed and capital which enabled adoption of new varieties. Furthermore, the study indicated that in the absence of public intervention resource poor and marginal farmers lacking market access, household assets, human capital and farm size may lag behind or face stiff barriers that may exclude them from harnessing new technologies.

The double hurdle model was also used by Olwande, Sikei and Mathenge (2009) on a ten year panel household survey data for 1,275 households to examine the determinants of fertilizer adoption and use intensity in Kenya. The first hurdle was a sample selection model estimated with a probit model. The second hurdle involved an outcome equation which used a truncated model to determine the extent of adoption (intensity of use) of the technology. Results of the study indicated that the proportion of household using fertilizer increased dramatically in the last decade while fertilizer application rates increased marginally. The results further indicated that age, education, credit, presence of cash crop, distance to fertilizer market and agro ecological

potential are statistically significant in influencing the probability of adopting fertilizer. The strongest determinant of fertilizer use intensity were gender, dependency ratio, credit, presence of cash crop, distance to extension service and agro ecological potential. The study provides a useful guide to the present one in terms of estimation of the intensity of adoption of technology.

Gebremedhin and Swinton (2003) used a double hurdle statistical analysis of 250 farms in the Tigray region of Ethiopia. The dependent variables were stone terraces and soil bunds. The explanatory variables were market access factors; physical factors, capacity factors, land tenure security factors, socio-institutional factors and household demographic factors. A likelihood ratio test rejected the Tobit model in favour of the double hurdle model. Results of the study indicated that factors affecting level of investment were different from those that affect the decision to invest. Whereas capacity factors largely influenced the adoption decision, expected returns carried more influence for the intensity of stone terrace adoption (measured as metres of terrace per hectare). The opportunity costs of labour and forgone land productivity were strong determinants of level of investment, despite making no significant contribution to the decision to invest. This suggests that activities that use labour in the dry season when bunds and terraces are constructed and maintained (such as migration, local off-farm activity and food-for-work programs) may compete with soil conservation.

Another author who used the double hurdle model was Worku (2011). He estimated the decision to adopt and on how much to invest in land conservation in the Ethiopian Highlands. Primary data collected through interview of rural households in three rounds in 2000, 2002 and 2004/5 was used for the study. The study used various techniques to analyse the data, including descriptive statistics and econometric analysis. The econometric analysis involved the use of the two-step double hurdle model. The adoption decision hypotheses were tested using probit regression equation whilst the intensity of adoption hypotheses were tested using truncated regression equation. Results of the study indicated that plot-level decision to adopt land conservation investment and plot-level decisions about how much to invest appear to be explained by different processes. The relevant policy and program tools for encouraging land conservation investment depends on whether or not farm-households are already convinced of the need to adopt land conservation investments at the specific plot. Poverty related factors (such as household characteristics and asset wealth endowment) seemed to have mixed effect on adoption as well as intensity decisions. While a farmer's adoption decision is influenced by whether or not the plot is owner operated (a measure of risk for the immediate period), intensity of conservation is measured by expectation on certainty to cultivate the land for the next five years, farmers' belief on land ownership and distance of plot from home.

In a related study, Ketema and Bauer (2012) explored the determinants of adoption and labour intensity of stone-terraces in Eastern Highlands of Ethiopia. The study used a household and plot-level data collected from 211 farm households and applied the double hurdle model for analysis. The probit regression was used to measure the decision to adopt whilst the truncated regression was used to estimate the intensity of adoption. Results of the study indicated that there are some differences in terms of magnitude and direction of determinants significantly affecting decisions to adopt terraces and its intensity in terms of labour use. The decision to adopt terraces and the decision on its intensity in terms of labour use are both positively and significantly affected by plot size, slope, and ownership of the parcel; training, age, and level of education of household head; proportion of land planted and involvement in off / non-farm activities. The two decisions were negatively and significantly affected by fertility status of the plot and the proportion of female members in the farm.

Most of the studies reviewed measured intensity in terms of area under cultivation. In the current study, however, intensity is measured by the degree of utilization of a particular input such as fertilizer or agro-chemical.

4.0 METHODOLOGY

4.1 Research design

Collection of data for the study was done through the survey method because of the wide area the study covered. The instrument for data collection was a questionnaire. The questions covered personal, socioeconomic, institutional and other relevant variables.

4.2 Study areas

The study was conducted in five regions namely Ashanti, Brong Ahafo, Central, Eastern and Western where cocoa is grown. Volta region was left out because according to COCOBOD (2011) output of cocoa from the Volta region is less than one percent of the total national output.

4.3 Study population

The population for the study was all cocoa farmers in Ghana. According to the report of the Ghana Statistical Service (2014), cocoa supports more than 794,129 smallholder households and the number of cocoa farmers is

estimated at 350,000. These farmers are found in all the cocoa growing regions. They consist of male and female, literate and non-literate farmers of diverse background and ages.

4.4 Determination of Sample Size

The sample size was determined using the following formula by Nassiuma (2000) for estimating sample size from a known population size and a coefficient of variation:

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Where
n = sample size
N = population size
C = coefficient of variation
e = error margin
Using a population size of 350,000 cocoa farmers, coefficient of variation of 35% and error margin of 1.5% the sample size was determined as:

$$n = \frac{350,000 * (0.35)^2}{(0.35)^2 + (350,000-1)(0.015)^2}$$

$$n = 542.77$$

This was approximated to 600 farmers.

4.5 Sampling procedure

Six hundred (600) farmers were selected through multistage sampling technique for the study. The first stage involved selection of districts and two districts from each region making a total of 10 districts were selected. The districts selected were Nkawie and Konongo in the Ashanti Region; Goaso and Dormaa in the Brong Ahafo Region; Assin Fosu and Twifo Praso in the Central Region; Koforidua and Asamankese in the Eastern Region; and Tarkwa and Sefwi Bekwai in the Western Region. The second stage involved the selection of villages or communities through random sampling and 10 districts were selected. The third stage involved the selection of farmers and six (6) farmers were selected from each district making a total of 600 farmers.

4.6 Survey instrument and procedures for data collection

The instrument for the study was a questionnaire which contained both closed and open-ended questions. It was divided into eight sections as follows: Section one dealt with farmer characteristics; section two considered farm characteristics; section three had questions on social participation; section four sought respondents' knowledge about cocoa research innovations; section five treated questions related to technology adoption; section six treated questions on measurement of intensity of technology adoption; section seven dealt with output of cocoa; and section eight dealt with credit access.

4.7 Pilot Study

The pilot study was done in the New Juabeng district with twenty (20) farmers purposively selected. The New Juabeng District was used for the pilot study because of its nearness to Akim Tafo where the Cocoa Research Institute of Ghana (CRIG) is located. The results of the pilot study led to modification of a few questions to make them clearer.

4.8 Test of reliability and validity of instrument

The services of cocoa extension officers were solicited to assist in testing the reliability of the questions. They reviewed the questions to ascertain whether they would elicit the type of responses expected. After that a pilot study was carried out. The data from the pilot study was analysed using SPSS (Statistical Package for Social Sciences). A reliability coefficient of 0.90 was obtained which was good.

4.9 Administration of questionnaire for the main study

The questionnaire was administered by cocoa extension officers. The questions were asked in the local language and so there was the problem of exact translation of the scientific terminologies into the local language. However because cocoa extension officers were used they were able to explain the terminologies to the farmers.

4.10 Data analysis

Some officers in the Ghana Statistical Service assisted in capturing information in the completed questionnaire into the Census and Survey Processing (CS Pro) system. The information was then exported to the Stata software for analysis. The descriptive statistics such as mean and standard deviation were obtained using appropriate commands in the Stata software. Also, the double hurdle model was estimated using appropriate commands.

5.0 DESCRIPTIVE STATISTICS

Descriptive statistics of the variables used in the model are provided in Table 1. They show details of number of observations, mean, standard deviation, minimum and maximum values.

Table 1 Descriptive Statistics for Variables

Variable	Description	Obs.	Mean	S. dev	Min	Max
Adoptintense	Intensity of Adoption	600	50.63	35.14	0	100
Age	Age in years	600	50.12	11.4	22	72
Hhsize	Household size	600	4.53	0.73	2	7
Farmsize	Farm size in Acres	600	4.90	1.15	2	10
Noedu	No formal Education (1/0)	130	0.22	0.41	0	1
Primedu	Primary education(1/0)	116	0.19	0.39	0	1
Midedu	JSS/Middle School(1/0)	302	0.50	0.50	0	1
Secedu	SSS/Technical/ Trg. Coll(1/0)	48	0.08	0.27	0	1
Tertedul	Tertiary (1/0)	4	0.01	0.081	0	1
Credit	Credit Access(1/0)	174	1.29	0.46	0	1
Hirelab	Hired labour	600	3.74	1.41	0	9
Ownlab	Own labour(1/0)	600	0.66	0.47	0	1
NonhiredLab	Non-Hired Labour	600	2.93	2.30	0	8
Memasso	Membership of Association	600	0.57	0.49	0	1
Frqadvice	Frequency of extension advice	600	0.74	0.47	0	20

Source: Own Survey Data
Note: No education is used as the reference category for education.

Intensity of adoption

Feder et al (1985) defined intensity of adoption as the level of adoption of a given technology (for instance the number of hectares planted with improved seed or the amount of fertilizer applied per hectare). Intensity of adoption measures the degree or extent of adoption of a technology. Intensity of adoption has been measured in several ways in literature. Nkonya, Schroeder and Norman (1997) measured the intensity of adoption as the number of hectares planted with improved seed or the amount of input applied per hectare. Mensah-Bonsu, Sarpong, Alhassan, Asuming-Brempong, Egyir, Kuwornu and Osei (2011); Paxton, Mishra, Chintawa, Roberts, Larson, English, Lambart, Marra, Larkin, Reeves and Martin (2011); and Masuki, Mutabazi, Tumbo, Rwehumbiza, Mattee and Hitabu (2006) defined intensity as the number of technologies adopted. Other researchers such as Kaguongo, Ortmann, Wale, Darroch and Low (2010); Nchida, Ambe, Nathalie, Leke, Che, Nkwate, Ngassam and Njualem (2010); and Asfaw, Shiferaw, Simtowe and Haile (2011) defined intensity of adoption as the proportion of area under the improved varieties.

In this study intensity of adoption is measured following the example of Opare (1980) using a scale 1 to 5. Farmers ranked the intensity of adoption of the various cultural practices such as weeding, spraying insecticides, fertilizer application, among others, as follow: very low (1), low (2), moderate (3), high (4) and very high (5). This scale was used in computing the intensity of adoption of a particular cultural practice and the result was expressed as a percentage. From the sample of 600 used for the study, the results obtained for intensity of adoption were 53.1%, 48.9%, 46.1%, 46.2%, and 56.4% for weeding, spraying, fertilizer application, fungicide application, fermentation and drying of cocoa respectively. In this study, Intensity of adoption is expected to positively affect output.

Age of the farmer
The age of the farmer determines whether the farmer is a youth or an aged. It is generally believed that the youth are more energetic and as such are able to perform more strenuous work. The majority (53%) of the farmers were between the ages 41 and 50 years and the average age was 50.12 years. This suggests that most of the farmers are of middle age. This finding almost agreed with the finding of Boahene (1995) who had the average age of farmers as 53 years.

Household size
This refers to members of household who performed certain activities on the cocoa farm. The study indicated that the size of the household ranges from 2 to 7 and the average was 4.53 (approximately 5 people). 46.2 per cent of the respondents had household size of five (5). This finding is consistent with what is contained in the Round Five (5) of the Ghana Living Standard Survey (2008).

Farm size
In Ghana most cocoa farmers are small holders who use family lands or lease them. The farm sizes are therefore not big. About 57.8% of the farmers had farm sizes between 2 and 10 acres and the average farm size was 4.9 acres. The farm sizes conform to the general characteristics of cocoa farmers who are basically small holders. The farmers do not usually have large plantations. In the past the government used to have large plantations but these were sold to individual farmers and companies.

Level of education
Level of education was categorised into no education, primary education, middle school/junior secondary school education, senior secondary school education and tertiary education. The majority of the farmers (50.3%) had middle school or junior secondary school education. Those who had tertiary education were less than 1%.

Credit access
It is a summary of the responses of farmers with regards to the funding of their operations from borrowing either from financial institutions or non-bank financial institutions. About Seventy one (71) per cent of the respondents had no access to credit. This implies only 29 per cent of the respondents had access to credit. The result is consistent with other studies (Asamoah 2015; Akudugu 2012 & Dabone et al 2014) which recorded low access to credit.

Hired labour
This refers to labourers who are paid to work on the farm. They may be casual labourers or permanent labourers. Most farmers usually hired about 4 labourers.

Own labour
Own labour refers to the man-hours the farmer himself uses on his farm. The study shows that about 66.2% of the respondents used their own labour. The finding exhibits the general characteristic of small holder farmers who perform activities on their farms themselves because of lack of funds to hire labourers and also due to the fact that they consider farming to be their occupation.

Non-hired labour
Non-hired labour refers to the engagement of services of people who are not paid any wage on the farm. They usually include friends or members of a cooperative group who visit the farms of members on rotational basis to assist each of the members in the group perform certain activities such as weeding, plucking of cocoa and breaking the pods. About 28.67% of the respondents engaged 3 non-hired labourers each on their farms.

Membership of association
A greater percentage of the respondents (57.17%) indicated that they belonged to cocoa producer association such as the Cocoa Abrabopa Association or Kuapa Kookoo Farmers Association. In such associations members are taught how to cultivate cocoa and discuss pertinent issues bordering on the production of cocoa.

Frequency of Extension advice
Frequency of extension advice refers to the number of times farmers were visited in a year. About 33.5% of the respondents indicated that they were visited at least once a year by extension officers. These extension officers were from the Ministry of Food and Agriculture or COCOBOD. They usually provided advisory services on how to handle a particular problem such as fertilizer application or proper management of disease and pests on the

farm.

6.0 EMPIRICAL MODEL FOR DETERMINANTS OF INTENSITY OF ADOPTION

The empirical model for estimation of the determinants of intensity of adoption is given as follows:

$$Adopt\,\text{int}\,ense = \beta_0 + \beta_1 Age + \beta_2 hhsize + \beta_3 farmsize + \beta_4 Primedu + \beta_5 Midedu + \beta_6 Secedu + \beta_7 Tertedu + \beta_8 credit + \beta_9 hiredlab + \beta_{10} Ownlab + \beta_{11} Nonhiredlab + \beta_{12} memasso + \beta_{13} freqadvice + \varepsilon \quad \text{... (4)}$$

The expected signs of the coefficients are:

$B_1 < 0;\ \beta_2 > 0;\ \beta_3 > 0;\ \beta_4 > 0;\ \beta_5 > 0;\ \beta_6 > 0,\ \beta_7 > 0;\ \beta_8 > 0;\ \beta_9 > 0;\ \beta_{10} > 0;\ \beta_{11} > 0;\ \beta_{12} > 0;\ \beta_{13} > 0$

Where *Adoptintense* is intensity of adoption of cocoa research innovations; *Age* is farmer's age; *hhsize* is household size; *farmsize* is the size of the farm; *Primedu* refers to primary education; *Midedu* is junior secondary/middle school education; *Secedu* is secondary education, *Tertedu* is tertiary education, *credit* is access to credit; *hirelab* is hired labour; *ownlab* refers to farmer's own labour, *Nonhiredlab* refers to non-hired labour such as spousal labour and reciprocal labour, *memasso* refers to membership of an association, *freqadvice* refers to frequency of extension advice and ε is the error term.

7.0 RESULTS AND DISCUSSIONS

The log likelihood estimate of -2403.22 with statistically significant chi-square of 103.84 indicated that the explanatory variables jointly determined the intensity of adoption of cocoa research innovations. Results of the double hurdle model are presented in Table 2. The first hurdle measures the adoption decision whilst the second hurdle measures the extent of adoption.

A general view of the results indicates that six (6) of the variables in the first hurdle out of the total number of thirteen (13) variables were significant while ten (10) variables in the second hurdle were significant. The larger number of significant variables in the double hurdle model suggests that the variables under consideration best explain the intensity of adoption than the decision to adopt the use of cocoa research innovations.

Age of the farmer (household head)

Age is not significant in the first hurdle implying it had no significance in the probability of adoption of cocoa research innovations. Age is however significant in the second hurdle suggesting that the extent to which cocoa technologies is adopted is influenced by age of the farmer. The finding is consistent with that of Maddison (2006), Nhemachena and Hassan (2007) and Ashenafi (2007) who argue that older farmers tend to intensify the adoption of new technologies in their farming business as a result of more years of farming experience, higher capital accumulation and large family sizes as a source of family labour. The possible explanation for this is that older farmers intensify the use of the technology once they are convinced of its usage. In other words, older farmers will tend to stick to a particular technology for a long time and intensify its usage. This finding is in contrast with the hypothesis and the finding of Langyintuo and Mulegetta (2005) and Baidu-Forson (1999) that had a negative relationship between age and intensity of adoption.

Household size

The coefficient of household size in the adoption model is positive but not statistically significant. However, the coefficient of household size in the second hurdle is negative and statistically significant at 10% level of significance. The results support the hypothesis that households with more members are likely to intensively adopt cocoa technologies because of availability of labour for cocoa production. The finding agrees with the stated hypothesis and the findings of Doss (2006) and Manyong and Houndekon (1997) who found household size to be positively related to intensity of adoption of technology.

Farm size

Farm size was significant in only the second hurdle at 1 per cent level of significance and had a positive coefficient. This means the size of the farm positively affects the intensity of adoption of cocoa research innovations. Thus, the finding confirms the stated hypothesis which postulated a positive relationship between farm size and intensity of adoption. The finding agrees with Abera (2008) who found positive relationship between intensity of herbicides use and farm size. A possible explanation for the positive relationship between farm size and intensity of adoption of cocoa research innovations is that, other things being equal, the farmer will get higher output and income from a large farm than a small farm. Part of this income can be used to acquire greater quantities of the needed inputs for the adoption of the new technology.

Education

Primary education and tertiary education were significant in the first hurdle whereas middle school education and tertiary education were significant in the second hurdle. The findings indicate that intensity of adoption of cocoa research innovation by farmers who have primary and middle school or junior secondary was positive. This implies that farmers with some level of formal education were able to adopt agricultural technologies as compared to farmers without any level of formal education. The finding agrees with those of Weir and Knight (2000), Forster and Roseweig (1996), Forster and Stem (1979), Ervin and Ervin (1982), Oluyole (2005) and Ben-Houssa (2011). Thus, the hypothesis that there is a positive relationship between education and intensity of adoption of cocoa research innovations is partially confirmed.

Credit access

Access to credit was significant at 1 per cent level of significance in the first hurdle but not significant in the second hurdle. Thus, credit access had a positive and significant influence on the decision to adopt but not the intensity of adoption of cocoa research innovations. This finding suggests that credit access may enable farmers adopt cocoa research innovations; however the extent to which they adopt will not be dependent on the availability of credit.

Hired labour

Hired labour was significant in the second hurdle and had a positive coefficient of 0.023. Thus, hired labour made it possible for the farmer to get the required labour to intensify the adoption of cocoa research innovations. The finding agrees with the stated hypothesis and those of Ben-Houassa (2011) and Aneani, Anchiranah, Owusu-Ansah and Asamoah (2012) who observed that availability of hired labour positively affected intensity of technology adoption.

Table 2: Determinants of Intensity of Adoption of Cocoa Research Innovations.

Variables	Description	First Hurdle Adoption Logit	Second Hurdle Intensity of Adoption Poisson
age	Age of farmer	0.0048435	0.0014271***
		(0.011926)	(0.0005768)
hhsize	Household size	0.214519	- 0.0142884*
		(0.1549927)	(0.0077493)
farmsize	Farm size	0.1365432	0.154014***
		(0.1063224)	(0.0047392)
Primedu	Primary education	0.8613739*	-0.0125203
		(0.4103278)	(0.0178442)
Midedu	JSS/Middle School	0.1521579	0.553461***
		(0.2976778)	(0.0156403)
Secedu	SSS/Technical/Training College	-0.0460921	- 0.028314
		(0.458889)	(0.024275)
Tertedu	Tertiary	12.4288***	0.1410569**
		(960.4916)	(0.0673002)
Credit	Credit Access	1.518119***	-0.006337
		(1.005)	(0.0144732)
Hiredlab	Hired labour	0.2890325	0.0231022***
		(0.0813847)	(0.0036952)
Ownlab	Own labour	1.501546***	0.0796173***
		(0.272876)	(0.0141642)
Nonhiredlab	Non-hired labour	-0.039343	0.0303288***
		(0.0853984)	(0.0042773)
Memasso	Membership of Association	1.357104***	0.0270977*
		(0.2578498)	(0.0141121)
Freqadvice	Frequency of extension advice	0.288038***	0.0359775***
		(0.0144229)	(0.0058845)
Constant		-2.094311*	4.209369***
		(1.174088)	(0.0570707)
Observations		600	600

Standard errors in parentheses
*** p<0.001, ** p<0.05, * p<0.1

Non-hired labour
Non-hired labour was significant in the second hurdle only at 1 per cent level of significance and had a positive coefficient. The finding agrees with the stated hypothesis and the finding of Boahene (1995) who observed that cooperative labour had a positive and significant impact on the percentage area of land used for hybrid cocoa.

Own labour
Own labour was significant in both hurdles and was significant at a level of 1 per cent. Also, it had positive coefficient in both hurdles implying own labour is positively related to adoption and intensity of adoption of cocoa research innovations. The finding agrees with that of Hicks and Johnson (1974) who observed a positive relationship between own labour and adoption of technology. The finding in this study indicates that farmers who own their farms are prepared to sacrifice to adopt cultural practices which will enhance their output.

Membership of an association
Membership of association was significant at a level of 1 per cent in the first hurdle and 10 per cent in the second hurdle. The coefficient was positive in both equations implying that there was a positive relationship between membership of an association and intensity of adoption of cocoa research innovations. Thus, the stated hypothesis has been confirmed.

Frequency of extension advice
Frequency of extension advice had positive effects in both hurdles and significant at 10 per cent level of significance. The result confirms the stated hypothesis that intensity of adoption is positively related to frequency of extension advice, a position held by Baah and Anchiranah (2011).

8.0 CONCLUSIONS AND RECOMMENDATIONS

This paper considered the determinants of intensity of adoption of cocoa research innovations in Ghana. The results indicate that factors which significantly affect intensity of adoption of cocoa research innovations were age of the farmer, household size, farm size, education and hired labour. Other factors were own labour, non-hired labour, membership of association and frequency of extension advice.
In the light of the above findings, the following are recommended:

1. COCOBOD should increase in scholarships to children of cocoa farmers and increase the fund allocation to the Ministry of Roads and Highways for improvement of roads in the cocoa growing communities to encourage the youth to go into cocoa farming in order to replace the aged farmers.
2. Government should promulgate laws to facilitate easy acquisition of land.
3. COCOBOD and LBCs should educate cocoa farmers through non-formal education in the cocoa farms to enable them appreciate the importance of adopting the recommended cocoa technologies.
4. COCOBOD and LBCs should encourage cocoa farmers to join producer associations where techniques of cocoa farming are discussed, marketing associations and credit unions.
5. COCOBOD should intensify the extension services provided to cocoa farmers to enable them adopt and use the technologies developed by CRIG.

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