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Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions?

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Abstract

Low adoption of modern agricultural production technologies amongst farmers in Ghana has been identified as one of the main reasons for the low agricultural productivity in the country. This paper examines the factors that influence farm households' modern agricultural production technology adoption decisions in Ghana. Household questionnaires were administered to 300 farmers the Bawku West District of Ghana; and the logit model was estimated to ascertain the factors. The results showed that farm size, expected benefits from technology adoption, access to credit and extension services are the factors that significantly influence technology adoption decisions of farm households in the study area. It is concluded that farm households' agricultural technology adoption decisions depends on their socio-economic circumstances and institutional effectiveness. We recommend that policies should be formulated to take advantage of the factors that positively influence farmers' adoption of modern agricultural production technologies and to mitigate the negative ones.

Key words: Agriculture, Farmers, Household, Logit Model, Ghana, Technology Adoption

1. Introduction

The economy of Ghana is basically agrarian. This is against the backdrop that agriculture contributes about 35 percent to the Gross Domestic Product (GDP) of the country (ISSER, 2010). Besides, agricultural activities constitute the main use to which Ghana's land resources are put. The agricultural sector is the major source of occupation for about 47 percent of the economically active age group of Ghanaians (Wayo, 2002). Despite the fact that the country covers an area of approximately 239 thousand square kilometres of which agricultural land forms about 57 percent of the total land area, only about 20 percent of this agricultural land across the different agro-ecological zones is under cultivation. This means that Ghana is yet, to fully utilise its natural resource base, particularly land for agricultural production.

The country's ability to fully utilise its agricultural production potential depends on the innovativeness of actors in the agricultural sector, particularly farmers. The capacity of farmers and actors along the agricultural value chain to innovate in their production activities is contingent on the availability of

technology. The Green Revolution in Asia as demonstrated in the empirical literature (see for instance David and Otsuka, 1994; Datt and Ravallion, 1998a, 1998b; DeJanvry and Sadoulet, 2002; Evenson and Gollin, 2003; Moser and Barrett, 2003; Minten and Barrett, 2008; among others) is an indication that improved technology adoption for agricultural transformation and poverty reduction is critical in modern day agriculture. Technical change in the form of adoption of improved agricultural production technologies has been reported to have positive impacts on agricultural productivity growth in the developing world (Nin *et al*, 2003). Promotion of technical change through the generation of agricultural technologies by research and their dissemination to end users plays a critical role in boosting agricultural productivity in developing countries (Mapila, 2011). The availability of modern agricultural production technologies to end users, and the capacities of end users to adopt and utilise these technologies are also critical. Unfortunately, the Ghanaian agricultural sector is characterized by low level of technology adoption and this according to Ghana's Ministry of Food and Agriculture (2010) contributes to the low agricultural productivity in the country. This is worrisome given that numerous interventions by successive governments have been implemented to promote technology adoption among farmers. Unravelling the reasons for low technology adoption among farmers requires that the factors that influence their decisions to adopt or not to adopt modern agricultural production technologies be identified.

This paper therefore examines the different factors that influence the adoption of modern agricultural production technologies among peasant farmers in the savannah agro-ecological zone of Ghana. Apart from the background, the paper presents the literature review in section 2; the methodology employed for the analysis which includes the survey process and analytical framework in section 3; the results and discussions in section 4; and finally, the conclusions drawn from the findings and recommendations made in section 5.

3. Literature Review

Different factors determine the adoption of different agricultural innovations and technologies. Much empirical adoption literature focuses on farm size as the first and probably the most important determinant (*See for instance* Shakya and Flinn, 1985; Harper *et al*, 1990; Green and Ng'ong'ola, 1993; Adesiina and Baidu-Forson, 1995; Nkonya *et al*, 1997; Fernandez-Cornejo, 1998; Baidu-Forson, 1999; Boahene *et al*, 1999; Doss and Morris, 2001; and Daku, 2002). This is because farm size can affect and in turn be affected by the other factors influencing adoption. The effect of farm size on adoption could be positive, negative or neutral. For instance, McNamara *et al* (1991); Abara and Singh, (1993); Feder *et al*, (1985); Fernandez-Cornejo, (1996) and Kasenge (1998) found farm size to be positively related to adoption. On the other hand, Yaron *et al*, (1992); and Harper *et al* (1990) found negative relationship between adoption and farm size. Interestingly, Mugisa-Mutetikka *et al* (2000) found that the relationship between farm size and adoption is a neutral one. With small farms, it has been argued that large fixed costs become a constraint to technology adoption (Abara and Singh, 1993), especially if the technology requires a substantial amount of initial set-up cost. In this regard, Feder *et al*, (1985) noted that only larger farms will adopt these kinds of innovations. With some technologies, the speed of adoption is different for small- and large- scale farmers which is critical for policy makers and implementers in Ghana in their pursuance of modernisation of

agriculture. In Kenya, for example, a study by Gabre-Madhin and Haggblade (2001) found that large commercial farmers adopted new high-yielding maize varieties more rapidly than smallholders.

Age is an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. However, there is contention on the direction of the effect of age on adoption. Age was found to positively influence adoption of sorghum in Burkina Faso (Adesiina and Baidu-Forson, 1995), IPM on peanuts in Georgia (McNamara *et al*, 1991), and chemical control of rice stink bug in Texas (Harper *et al*, 1990). In contrast, age has been found to be either negatively correlated with adoption, or not significant in farmers' adoption decisions. In studies on adoption of land conservation practices in Niger (Baidu-Forson, 1999), rice in Guinea (Adesiina and Baidu-Forson, 1995), fertilizer in Malawi (Green and Ng'ong'ola, 1993), IPM sweep nets in Texas (Harper *et al*, 1990), Hybrid Cocoa in Ghana (Boahene *et al*, 1999), age was either not significant or was negatively related to adoption.

A number of studies that sought to establish the effect of education on adoption in most cases relate it to years of formal schooling (Tjornhom, 1995, Feder and Slade, 1984). Generally, education is thought to create a favourable mental attitude for the acceptance of new practices, especially information-intensive and management-intensive practices (Waller *et al*, 1998; and Caswell *et al*, 2001). According to Rogers (1983) and Ehler and Bottrell (2000), technology complexity has a negative effect on adoption and this could only be dealt with through education. Gender issues in agricultural production and technology adoption have been investigated for a long time. Most of such studies show mixed evidence regarding the different roles men and women play in technology adoption. Doss and Morris (2001) in their study on factors influencing improved maize technology adoption in Ghana, and Overfield and Fleming (2001) studying coffee production in Papua New Guinea show insignificant effects of gender on adoption. Furthermore, access to funds including credit is expected to increase the probability of adoption. For instance, it has been reported that most small scale farmers in the country are unable to afford basic production technologies such as fertilisers and other agrochemicals resulting in low crop yields due to poverty and limited access to credit (Ministry of Food and Agriculture 2010).

From the foregoing, it is concluded that though a number of studies have been conducted across the world on technology adoption, there is dearth of literature on the specific factors that influence modern agricultural production technologies, especially among small scale farmers in Ghana. This is a serious gap that must be bridged if the problem of low technology adoption among farmers is to be addressed and agricultural productivity improved.

3. The Methodology

3.1 The Survey

The study was conducted in the Bawku West District of the Upper East Region of Ghana in 2011. Multistage sampling was employed in the study. The first stage was purposive selection of the Bawku West District because of the fact that it has a large population of small scale farmers practicing traditional farming systems relative to other districts in the country. The district is divided into seven (7) Area/Town

Councils under the Local Government Structure of Ghana. The second stage was the selection of five (5) out of the seven (7) Area/Town Councils using simple random sampling. The third stage was to divide each sampled Area/Town Council into two strata – North and South. The fourth stage was to select one (1) farming community from each stratum which gave a total of two communities per selected Area/Town council and ten farming communities in all. The fifth stage was to divide each sampled community into five (5) strata – North, East, South, West and Central. The sixth and final stage was the selection of three (3) farm households from each stratum in each sampled community using simple random sampling. This gave a total of fifteen (15) farm households per selected farming community and one hundred and fifty (150) farm households in all. In each sampled household, one adult male, preferably the household head and one adult female, preferably the wife of the household head were interviewed using a household questionnaire. This gave a sample size of three hundred (i.e. 150 men and 150 women). The pieces of information gathered from the interviews were the basic inputs for analyses. STATA (Version10) was the software used for the data analyses.

3.2 The Analytical Framework

Using the logit model, the factors that influence farm households' decisions to adopt modern agricultural production technologies were estimated. The use of the logit model for this analysis is consistent with the literature on adoption (*see for instance* Griliches, 1957; Lionberger, 1960; Rogers, 1983; Alston *et al*, 1995) which describes the process of adoption as taking on a logistic nature. The study used the threshold decision-making theory proposed by Hill and Kau (1973) and Pindyck and Rubinfeld (1998. The theory points out the fact that when farmers are faced with a decision to adopt or not to adopt a technology, there is a reaction threshold which is dependent on a certain set of factors. As such, at a certain value of stimulus below the threshold, no adoption is observed while at the critical threshold value, a reaction is stimulated. Such phenomena are generally modeled using the relationship:

$$Y_i = \beta X_i + u_i \quad (1)$$

Where Y_i is equal to one (1) when a choice is made to adopt and zero (0) otherwise; this means:
$Y_i = 1$ if X_i is greater than or equal to a critical value, X^* and
$Y_i = 0$ if X_i is less than a critical value, X^*.

Note that X^* represents the combined effects of the independent variables (X_i) at the threshold level.

Equation 1 represents a binary choice model involving the estimation of the probability of adoption of a given technology (Y) as a function of independent variables (X). Mathematically, this is represented as:

$$Prob(Y_i = 1) = F(\beta' X_i) \quad (2)$$

$$Prob(Y_i = 0) = 1 - F(\beta' X_i) \quad (3)$$

Where Y_i is the observed response for the i^{th} observation of the response variable, Y. This means that Y_i = 1 for an adopter (i.e. farmers who adopt modern agricultural production technologies) and Y_i = 0 for a non-adopter (i.e. farmers who do not adopt modern agricultural production technologies). X_i is a set of

independent variables such as farm size among others, associated with the i^{th} individual, which determine the probability of adoption, (P). The function, F may take the form of a normal, logistic or probability function. The logit model uses a logistic cumulative distributive function to estimate, P as follows (Pindyck and Rubinfeld, 1998):

$$P(Y=1) = \frac{e^{\beta' X}}{1+e^{\beta' X}} \quad (4)$$

$$P(Y=0) = 1 - \frac{e^{\beta' X}}{1+e^{\beta' X}} = \frac{1}{1+e^{\beta' X}} \quad (5)$$

According to Greene (2008), the probability model is a regression of the conditional expectation of Y on X giving:

$$E(Y/X) = 1[F(\beta' X)] + 0[1 - F(\beta' X)] = F(\beta' X) \quad (6)$$

Since the model is non-linear, the parameters are not necessarily the marginal effects of the various independent variables. The relative effect of each of the independent variables on the probability of adoption is obtained by differentiating equation (6) with respect to X_{ij} resulting in equation (7) (Greene, 2008):

$$\frac{\partial P_i}{\partial X_{ij}} = \left[\frac{\lambda^{\beta' X}}{\left(1+\lambda^{\beta' X}\right)^2}\right]\beta = F(\beta' X)[1 - F(\beta' X)]\beta \quad (7)$$

The maximum likelihood method was used to estimate the parameters.

The implication for applying the logit model in this paper is that, the farmer would decide to adopt modern agricultural production technologies at a given point in time when the combined effects of certain factors exceed the inherent resistance to change in him/her. The preference for the probability model (logit) to the conventional linear regression models, in analysing the factors influencing the decisions of farm households' to adopt modern agricultural production technologies is based on the fact that, the parameter estimates from the former are asymptotically consistent and efficient. The estimation procedure employed also resolves the problem of heteroscedasticity and constrains the conditional probability of making the decision to adopt technology to lie between zero (0) and one (1). Logit model is chosen over probit model in this paper primarily because of its mathematical convenience and simplicity (Greene, 2008) and the fact that it has been applied in similar studies by Green and Ng'ong'ola (1993); Kato (2000); Boahene *et al.* (1999); Nkonya *et al.* (1997); Shakya and Flinn (1985); Feder *et al.* (1985); and Rogers (1995).
The empirical model for the logit model estimation is specified as follows:

$$z_i = log\frac{P_i}{1-P_i} = \alpha + \beta X_i + \varepsilon_i \quad (8)$$

Where X_i is the combined effects of X explanatory variables that promote or prevent farmers' decision to adopt modern agricultural production technologies.

$log \frac{P_i}{1-P_i} =$ The log-odds in favour of farm households' decision to adopt modern agricultural production technologies

$X_1...X_i$ are factors that promote or prevent farm households' from adopting modern agricultural production technologies and are defined as follows: X_1 = Farm size in hectares; X_2 = Cost of technology, dummy (1 = Affordable; 0 = Otherwise); X_3 = Level of expected benefits, dummy (1 = High expected benefits; 0 = Otherwise); X_4 = Has off-farm income generating activities, dummy (1 = Yes; 0 = Otherwise); X_5 = Age of respondent in years; X_6 = Maximum level of education in the household measured as years of formal schooling; X_7 = Gender of respondent, dummy (1 = Man; 0 = Otherwise); X_8 = Access to credit, dummy (1 = Has access to credit; 0 = Otherwise); X_9 = Access to extension services, dummy (1 = Has access to extension; 0 = Otherwise).

4. Results and Discussions

4.1 Socio-Demographic Characteristics of Respondents

The study results revealed that majority (93%) of farm household heads and their partners in the Bawku West District of the Upper East Region of Ghana are between 18 and 60 years of age and are presumed to be driving the households' decision making processes on the adoption of modern agricultural production technologies (Table 1). The implication of this finding is that most farm households in the district belong to the economically active age group and their technology adoption behaviours are critical for the improvement of agricultural productivity and farm household welfare in the district. Further, 50 percent of the respondents were men with the remaining 50 percent of them being women. This implies that, the outcome of the study represents the collective views, concerns and opinions of both men and women with regards to the adoption of modern agricultural production technologies. Majority of the respondents (52%) did not have any form of formal education. Besides, 30 percent of the respondents had basic education and 18 percent of them post-basic education (Table 1). This means that the findings are representative of both literate and illiterate residents of the Bawku West District of the Upper East Region of Ghana. It also implies that people with appreciable level of formal education seek employment in the non-farm economy.

4.2 Factors Influencing Farm Households' Modern Agricultural Production Technologies Adoption

The factors influencing farm households' adoption of modern agricultural production technologies using the logit model were grouped into three main categories namely economic, social and institutional factors. The economic factors included farm size, cost of adoption, access to credit, expected benefits from the adoption and the off-farm income generation activities that farm households engage in. The social factors included the age of farmers, the level of education and the gender. The institutional factors included access to extension services. The logit model estimation gave a Pseudo R^2 of 0.6785 (Table 2) which implies that the variables included in the model are able to explain about 68 percent of the probability of farm households' decisions to adopt or not to adopt modern agricultural production technologies. The Log-likelihood Ratio (LR) was also found to be significant at the 1 percent level (Table 2). This means that all the explanatory variables included in the model jointly influence farmers' probability of adoption of

modern agricultural production technologies. The model results also gave a predicted probability of adoption to be of 0.6956. This means that there is about 70 percent probability that farm households in the Bawku West district of the Upper East Region of Ghana are willing to adopt modern agricultural production technologies provided some social, economic and institutional bottlenecks that hinder technology adoption are addressed. Given the foregoing goodness of fit measures, it is concluded the logit model employed had integrity and hence appropriate.

Farm size was found to have a positive relationship with the probability of adoption of modern agricultural production technologies (Table 2). It was found to be significant at the 1 percent level. This finding is consistent with the literature that large scale farmers are more inclined to adopting new technologies than small scale farmers (*see for example* McNamara *et al*, 1991; Abara and Singh, 1993; Feder *et al,* 1985; Fernandez-Cornejo, 1996; and Kasenge, 1998). This presents a serious challenge to policy makers and implementers in promoting the adoption of modern agricultural production technologies in the study area. This is because majority of farm households in the district operate on small scale with average farm sizes hardly exceeding five hectares.

The cost of modern agricultural production technologies was found to be negatively related to the probability of adoption (Table 2). It was however, found to be insignificant. The finding is consistent with Caswell *et al* (2001) who noted in their study that the decision to adopt a new technology presents a shift in farmers' investment options. This means that if the technology is costly to the farmer, there is low probability that he or she will adopt it. Besides, the fear of losing livelihoods is a social cost that farmers consider in their adoption decisions. For instance, a farmer whose main source of livelihood is maize farming will hesitate to replace this crop with improved groundnut cultivation for the fear that if the crop fails his or her livelihood will be greatly affected. In effect, as note by Oster and Morehart (1999), technologies that are capital-intensive are only affordable by wealthier farmers and hence the adoption of such technologies is limited to larger farmers who have the wealth (Khanna, 2001). This explains why there is low adoption of modern agricultural production technologies in the study area and Ghana as a whole because most of the technologies are not affordable to farm households most of who are small scale operators. Efforts to encourage the adoption of modern agricultural production technologies must focus on coming out with technologies that are affordable especially to poor rural dwellers about 90 percent of who depend on agriculture for their livelihoods.

The expected benefit to be derived from adopting a given technology was found to be positively related to the probability of adoption (Table 2). This was found to be significant at the 10 percent level. This implies that if farmers expect benefits from adopting a modern agricultural production technology to be higher than their current methods of farming, they are most likely to adopt it and the vice versa. This is consistent with Abara and Singh (1993) who observed that without a significant difference in outcomes between two options, and in the returns from alternative and conventional practices, it is less likely that farmers, especially small-scale farmers will adopt the new practice. Off-farm activities though insignificant were found to have a negative relationship with the probability of adoption. This implies that the higher the off-farm activities, the lower their probability of adoption of modern agricultural production technologies.

This is in line with the observation made by Mugisa-Mutetikka *et al* (2000) that practices that heavily draw on farmers' leisure time may inhibit their adoption of on-farm technologies. Also, the age of farmer assumed a quadratic function which implies that farmers' rate of adoption is low at both the younger and older ages (Table 2). It was found to be significant at the 10 percent level. At the younger age, farmers may not be able to adopt modern agricultural production technologies, especially capital intensive ones because of the fact that they might not have adequate resources to do so. At an older age, farmers' volume of economic activities reduced hence they may be unable to pay for technologies. Besides, older farmers have accumulated years of experience in farming through experimentation and observations and may find it difficult to leave such experiences for new technologies. In addition, farmers' perception that technology development and the subsequent benefits, require a lot of time to realize, can reduce their interest in the new technology because of farmers' advanced age, and the possibility of not living long enough to enjoy it (Caswell *et al*, 2001; Khanna, 2001). Elderly farmers often have different goals other than income maximization, in which case, they will not be expected to adopt an income –enhancing technology (Tjornhom, 1995).

The maximum level of education within the farm household was found to have a positive relationship with the probability of adoption and significant at 1 percent level (Table 2). The implication of this is that farm households with well educated members are more likely to adopt modern agricultural production technologies than those without. This is because educated members even bring home modern agricultural production technologies, especially improved crop varieties and livestock breeds for relatives to adopt. This is consistent with the literature that education creates a favourable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive practices (Waller *et al*, 1998; Caswell *et al*, 2001). Besides, gender was found to be positively related to the adoption of modern agricultural production technologies by farm households (Table 2). This was found to be significant at 1 percent level. This means that male farmers are more likely to adopt modern agricultural production technologies their female counterparts. The reason for this is that men are the people who make production decisions in the study area and also control productive resources such as land, labour and capital which are critical for the adoption of new technologies. This finding contradicts those of Doss and Morris (2001) who in their study on factors influencing improved maize technology adoption in Ghana, and Overfield and Fleming (2001) studying coffee production in Papua New Guinea show insignificant effects of gender on adoption. Access to credit was found to have a positive relationship with the probability of adoption. This was found to be significant at the 1 percent level (Table 2). This means that credit is an important facilitating factor of agricultural production technology adoption. This is consistent with the view that high poverty levels among farmers and lack of access to credit make it almost impossible for them to afford technologies (Ministry of Food and Agriculture, 2010). This is particularly so given that most modern technologies are expensive which makes it difficult for many farmers, especially those in rural areas where poverty is endemic to be able to acquire and utilise them without assistance in the form of supply of affordable credit and other financial services (Benin *et al*, 2009).

Access to extension services is critical in promoting adoption of modern agricultural production

technologies because it can counter balance the negative effect of lack of years of formal education in the overall decision to adopt some technologies (Yaron *et al*, 1992). Access to extensions services therefore creates the platform for acquisition of the relevant information that promotes technology adoption. Access to information through extension services reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time thereby facilitating adoption. Related to this is access to extension services which was also found to be positively related to the adoption of modern agricultural production technologies and was found to be significant at 10 percent level. This means that farm households are more likely to adopt modern agricultural production technologies if they have access to extension services.

5. Conclusion

The factors that influence the adoption of modern agricultural production technologies are broadly categorised into economic factors, social factors and institutional factors. The economic factors include farm size, cost of technology or modernization, expected benefits from adoption of the technology, and off-farm activities. Farm size and the expected benefits are the only significant economic factors that influence the decisions of farm households in the Bawku West District of the Upper East Region of Ghana to adopt modern agricultural production technologies. The social factors that influence probability of adoption of modern agricultural production technologies by farm households include age, level of education and gender. All these social factors were found to significantly influence the decisions of farm households in the Bawku West District of the Upper East Region of Ghana to adopt modern agricultural production technologies. Institutional factors including access to information and extension services were found to significantly influence farm households' probability of adopting modern agricultural production technologies in the Upper East Region of Ghana.

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Table 1: Socio-demographic characteristics of respondents

Age	**Frequency**	**Percentage (%)**
18-45	198	66
46-60	82	27
Greater than 60	20	7
Total	**300**	**100**
Gender	**Frequency**	**Percentage (%)**
Male	150	50
Female	150	50
Total	**300**	**100**
Education	**Frequency**	**Percentage (%)**
No formal	156	52
Basic	90	30
Post-basic	54	18
Total	**300**	**100**

Source: Field Survey Data, 2011

Table 2: Factors influencing technology adoption by farm households in Ghana

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Number of observations = 300; LR Chi Square (10) = 180.87; Prob.> Chi^2 = 0.0000; Log likelihood = -42.8544; Pseudo R^2 = 0.6785; Predicted Prob. (Adoption) = 0.6956

Variable	Coefficient	Std. Err.	z	P>|z|	dy/dx
Farm size	1.7326	.7007	2.47	0.013	.3576
Cost of technology	-0.7862	.6181	-1.27	0.203	-.1728
Expected benefits	1.1911	.6673	1.78	0.074	.2329
Off-farm activities	-0.2459	.6316	-0.39	0.697	-.0516
Age of farmer	-0.2435	.1411	-1.73	0.084	-.0516
Age of farmer squared	0.0023	.0012	1.81	0.070	.0005
Educational level of farmer	3.3817	.8153	4.15	0.000	.6837
Gender of farmer	1.7923	.6344	2.83	0.005	.3952
Access to information	2.3523	.6588	3.57	0.000	.4740
Extension services	1.3785	.8390	1.64	0.100	.3086
Constant	0.2723	3.7348	0.07	0.942	-

Source: Field Survey Data, 2011