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Agricultural Cooperatives and Improved Technologies Adoption among Smallholder Farmers in Cocoa-Based Farming Systems of Southwestern Nigeria

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Abstract

Cocoa productivity in Nigeria, has been declining in recent years. The declining productivity has been attributed to a lot of factors including slow adoption of improved technologies in cocoa-based farming systems. One of the efforts to accelerate improved technologies adoption process among cocoa farmers is through establishment of agricultural cooperatives. This study was therefore conducted to determine the effect of membership in agricultural cooperatives on the adoption of improved technologies in cocoa-based farming systems. A multi-stage sampling procedure was employed to select 200 respondents for the study. Data were analyzed using descriptive statistics, adoption index and Tobit regression model. The results for the entire respondents showed mean values of 52 years for age, 29 years for farming experience, 10 people for household size and 6 ha for farm size. The average adoption level of improved technologies was estimated at 37 percent in the study area. Based on the average adoption level, about 61 percent of the sampled population are classified as partial adopters, while 39 percent are full adopters of improved technologies. Tobit's regression estimates revealed that gender, household size, farm size, hired labour, extension visits, and membership in agricultural cooperative significantly influenced the probability and intensity of adopting of improved technologies in cocoa-based farming system. The study concluded that membership in agricultural cooperatives has a significant influence on the adoption of improved technologies. Therefore, the study recommends establishing an agricultural cooperative that ensures efficient and effective training on improved technologies, as well as the strengthening the agricultural cooperative in order to provide microcredit necessary for greater adoption of improved cocoa production technologies among farmers. Also, cocoa farmers should be encouraged to participate in agricultural cooperatives.

Keywords:
Improved technologies, cocoa farming systems, adoption level, agricultural cooperatives, farmers, Southwestern Nigeria

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INTRODUCTION

Perennial crops such as cocoa, coffee, cashew and oil palm constitute important components of smallholder farming systems across the humid tropics of West Africa including Nigeria. However, cocoa dominates the farming systems of Nigeria for its economic, social and environmental benefit, and even for the purpose of food security (Ayanlaja, 2000; Kehinde et al., 2021). Cocoa provides sustainable and equitable pathway for improving the welfare of farmers involved in its production (Nkamleu et al., 2010). Cocoa production is a major economic activity for over 650,000 households (Kolawole et al 2020; Kehinde and Tijani, 2021), with other 7 million Nigerians depending on cocoa supply chain for their source of income (Oyedele, 2007; NCDC, 2008; Agbongiarhuoyi et al., 2013; Kolawole et al., 2020; Uwagboe, 2020). However, despite cocoa's contribution to improving the welfare of farmers and other actors along its value chain, cocoa production has been decreasing till date (FAO, 2016; Alao et al., 2020). Statistics on cocoa production in Nigeria show that average cocoa production during the period of 2000 to 2010 was 389,272 tonnes per annum. The production declined to 192,000 tonnes per annum between 2015 and 2016 (ICCO, 2017). Although the production increased to 230,000 tonnes per annum from 2017 till date (ICCO, 2019), it has not met the potential or even the previous production volume before year 2000. The downturn in production is expected to affect the foreign exchange monetary value of the country and also, the welfare of the farmers. Though interventions are ongoing to strategically increase cocoa production, the efforts of increasing cocoa production in the country still remain fruitless.

This is evident in the fact that cocoa yields on individual cocoa farms are three to five times below the frontier. The observed cocoa yield is about 500 kg/ha on the average, against the potential yield of 1500, which could be up to 2500 kg/ha in some cases (Aneani and Ofori-Frimpong, 2013 and Wessel and Foluke Quist-Wessel, 2015). This could be ascribed to the fact that cocoa-based farming system in Nigeria is largely dominated by smallholder farmers with an area of one to five hectares. The smallholder farmers continue to produce below potential cocoa production figure due to old and moribund cocoa trees, traditional cultivation practice and use of simple crude tool. Key to improving yields on cocoa-based farms, is the introduction of improved agricultural technologies. In view of this, the Cocoa Research Institute of Nigeria (CRIN) and International Institute of Tropical Agriculture (IITA) have developed new agricultural technologies to improve yields on cocoa-based farms. Improved agricultural technologies can be defined as sustainable pathways which farmers increase and maintain their yields through the application of new inputs or practices that are economically viable, ecologically friendly and culturally acceptable (Aneani, 2012). World Bank (2008) and Heikkila et al. (2012) opined and concurred that investment in improved technologies such as improved seed varieties, fertilizer, herbicides and recommended agronomic practices could be fundamental way to significant increase agricultural production and stimulate production from small-scale to large-scale. Therefore, introducing improved technologies to small-scale farmers would improve their productivity by replacing the old method of farming by modern efficient techniques or practices (Otsuka, 2016), which translates into higher farm incomes and food security (Collier and Dercon, 2014; Mwangi and Kariuki, 2015; Dhehibi et al., 2020).

Despite the development and introduction of improved technologies by the existing research institutes, farmers have largely continued their old practices and use old technologies (Ayanlaja, 2000; Kehinde et al., 2018). As a matter of fact, majority of the cocoa farmers that have at a time adopted new technologies, have discontinued the adoption, hence the observed rate and intensity of adoption have been critically low (Oladele, 2005; Kehinde and Adeyemo, 2017; Kehinde et al., 2018). This has raised questions as to why adoption rates for improved technologies would remain low. The first question that springs to mind is that what are the reasons for low adoption rates? Meanwhile, failure to adopt new agricultural technologies continues to be a factor responsible for low yields in the cocoa-based farming system (World Bank, 2008; Omoregbee and Ekpebu, 2012; Kehinde and Adeyemo, 2017). To understand why farmers don't adopt new technologies, it is necessary to recognize the factors that determine the adoption behavior of a farmer. This is necessary because there are complex set of factors associated with technology adoption (Aikpokpodion et al., 2005; Oladele, 2005; Kehinde et al., 2018). However, it is disappointing that inappropriate identification of the main barriers of adoption remains a challenge (Solomon, 2010; Wossen et al. 2015; Wossen et al. 2017). Nevertheless, one of the most plausible reasons for low adoption by farmers is lack of access to credit (Aneani et al., 2012). For a technology to be successfully adopted, it must be affordable by farmers. Most improved cocoa technologies are particularly expensive for smallholder farmers to afford (NBS, 2012). This is attributed to the fact that the technologies require large initial investments which may be more difficult for smallholder farmers to access and acquire, whereas the technologies take many years to yield a benefit. More often than not, the farmers can only adopt subsets of the agricultural technologies package introduced to them (Pervez et al. 2018).

These continued challenges faced by these farmers spurred government, research institutes, extension and other developmental agencies to encourage farmers to form agricultural cooperatives. Cooperatives are increasingly seen as a means to promote improved agricultural technologies and alleviate food insecurity and poverty (Verhofstadt and Maertens, 2015; Ma and Abdulai, 2016; Mojo et al., 2017). This is so because cooperative societies are widely regarded as an important institutional innovation that can help overcome the constraints that impede and adoption of improved technologies (Wossen et al., 2017). Particularly, membership in agricultural cooperative is considered as a major force of knowledge and technological transfer based on its collective actions which facilitates innovation and learning by members of the society (Chagwiza et al., 2016). This is achieved through stimulating the exchange of information on the successful adoption of improved technologies. Also, agricultural cooperatives provide better and reliable access to credit facilities. This is attributed to the fact that, being a member of that cooperative, the farmer will have access to inputs, disclosure services, bargaining power in the market and credit. This is achieved through one of the recognizable characteristics of agricultural cooperatives, that farmers come together in cooperatives to pool their resources in order to meet needs that could not be solved with limited individual capacity (Wossen et al., 2017). In view of the above, encouraging farmers to join agricultural cooperatives and increase their stock of social capital by participating in these societies could provide a better platform for farmers to adopt new agricultural technologies.

There are well established research studies suggesting that agricultural cooperatives enhance the adoption of improved agricultural technologies (Abebaw and Haile, 2013; Wossen et al 2015; Ainembabazi et al 2017; Wossen et al 2017; Ma and Abdulai, 2017; Zhang et al 2019). However, this study differs from these related studies as it aimed at determining the effect of membership in agricultural cooperatives on the simultaneous decisions of rate and intensity of adopting improved technologies in cocoa-based farming system; none exists to the best knowledge of the author. Therefore, this study was conducted to fill the gap in the literature. To this end, this study attempts to provide empirical information on the effect of membership in an agricultural cooperative on rate and intensity of adopting improved technologies. Specifically, the study described the socio-economic characteristics of smallholder farmers within the cocoa-based farming system; profiled the types of agricultural cooperatives available within the cocoa-based farming system; determined the rate of adoption of improved technologies among smallholder farmers within cocoa-based farming system; and determined the effect of membership in agricultural cooperatives on rate and intensity of improved technologies adoption among smallholder farmers within cocoa-based farming systems. Through the results that emanate from this study, the study makes two major contributions. First is to advance the understanding of the factors of technology adoption for targeting efforts to increase productivity in cocoa-based faming systems of Nigeria. Second is that establish the relationship between agricultural cooperative and adoption of improved technologies in cocoa-based farming systems. These contributions will be useful for policy formulation.

METHODOLOGY

Study area

Two states in southwestern Nigeria make up the study area, namely the States of Oyo and Osun. The State of Oyo has five major groups; Ibadan, Ibrarapa, Oyo, Oke-ogun and Ogbomoso. It is characterized by two climatic seasons. The State is made up of 33 local government areas with a population of 5,591,585 people (National Population Commission, 2007). The favorable climate of the area has encouraged around 70 percent of the inhabitants to engage in small-scale agriculture. They grow both permanent and food crops. Farmers in the State are predominantly smallholders. The State of Oyo enjoys a dual climatic condition similar to the rest of the southwestern states, with a rainy season and a dry season. The climate is ideal for growing crops such as cocoa, maize, yam, cassava, millet, rice, banana and cashew. The State of Osun is an inland State with Osogbo as its capital. It has an area of approximately 14,875 km. Although it is a landlocked State, it is blessed with the presence of many rivers and streams that meet the water needs of the State. The State of Osun is made up of 30 local government areas with a population of 3,423,535 (National Census of Population, 2007). Farmers in the State are predominantly smallholders. The State of Osun has a dual climatic condition with a rainy season and a dry season. The crops planted include corn, cocoa, cassava, etc.

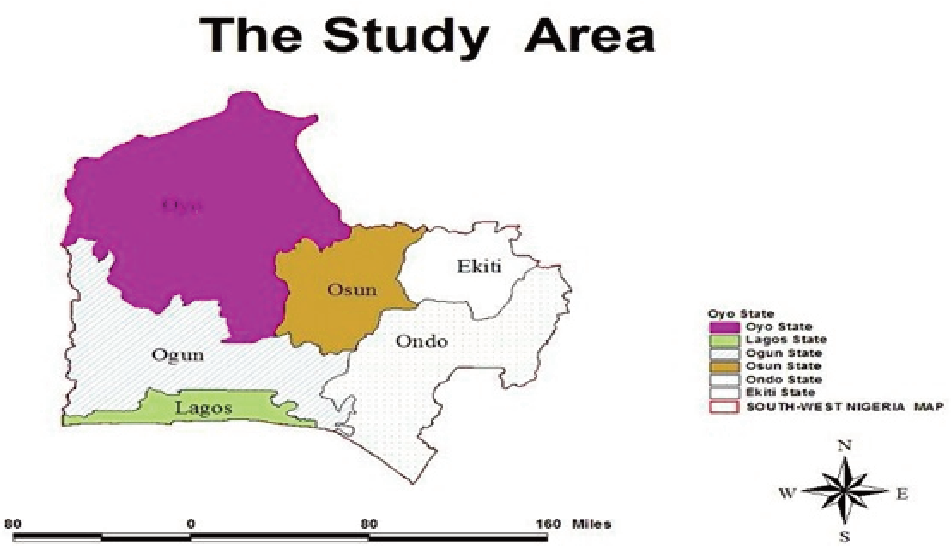

Figure 1. Map of Southwestern Nigeria

Sampling procedure and sample size

A multi-stage sampling procedure was used to obtain data for the study. The first stage involved randomly selecting the states of Osun and Oyo in southwestern Nigeria using simple random technique. The second stage was purposive selection of LGAs; Ido and Ogo-oluwa in Oyo State and LGAs; Atakumosa East and Ayedire in Osun State based on the predominance of cocoa farmers in LGAs. The third stage was the simple random selection of five villages from the list of cocoa producing villages in each of the four LGAs. The fourth stage involved the simple random selection of ten cocoa producing households in each village, generating a total sample of 200 cocoa-based farmers used for the study.

Data analysis

Data collected were analyzed using descriptive statistics, adoption index and Tobit regression model.

Descriptive statistics

Descriptive statistics (percentages, mean, and standard deviation) were used to describe the socio-economic characteristics of smallholder farmers within cocoa-based farming system.

Adoption index

Adoption index was used to determine the adoption level of improved technologies among the farmers within cocoa-based farming systems. In this study, five improved technologies were considered namely; improved seed varieties, fertilizer, pesticides, recommended spacing and recommended mixed cropping. For adoption of each technology, an adopter was coded as 1 while non-adopter was coded as 0. This study determined the adoption level (*x)* of a farmer using the adoption index employed by Shehu et al. (2013) and Kehinde et al. (2018):

$$AI_i = \sum (\frac{AT_i}{NT_i} \times 100) \quad (1)$$

where;

AI_i is the adoption Index of a farmer, AT_i is the number of technologies adopted by a farmer, NT_i is the number of technologies introduced. This study further adopted this formula by Kehinde (2020) to determine the average adoption level:

$$\text{Average adoption level} = \frac{\sum fx}{N} \quad (2)$$

where f = frequency of each value observed; N = number of observations of the variable x. The adoption index ranges from 0 to 1 depending upon the farmer's extent of technology adoption. The adoption score 0 point implies the non-adoption of the technology package. If the score is above the value of 1, it indicates the full adoption of the technology package. If a farmer's score is higher than the mean adoption index, he is a full adopter of improved technologies, if a farmer's score

Table 1

Sampling procedure for the study

State	LGAs	Villages		Cocoa farmers	
		Proportion used	Number of villages	Proportion used	Number of registered farmers
Osun	Atakumosa East	5	34	50	67
	Ayedire	5	49	50	78
Oyo	Ido	5	47	50	62
	Ogo Oluwa	5	37	50	69
Total	4	20		200	276

is less than the mean adoption index, he is a partial adopter of improved technologies.

Tobit regression model

The theoretical Tobit model

Many studies have assessed the determinants of technology adoption and have treated technology adoption as a binary variable using qualitative response models such as Logit or Probit model. Logit and Probit models are appropriate when the dependent variable is dichotomous (0, 1). In this study, the objective of this study goes beyond investigating determinants of technology adoption to analyze the intensity of the technology adoption, the study adopts therefore the Tobit model. This is because the Tobit model is an extension of the Probit model and it is useful for continuous values that are censored at or below zero as indicated in the dataset. When a variable is censored, regression models for truncated data provide inconsistent estimates of the parameters. The Tobit model assesses the probability of technology adoption as well as the intensity of technology adoption. The Tobit model is therefore viewed as hybrid of the discrete and continuous model which will simultaneously analyze the adopters' decision and the intensity of adoption subject to farmer's socioeconomic variables.

The Tobit model assumes that there is a latent unobserved variable that depends linearly on through a parameter vector . The normally distributed error term captures the random influence on the relationship. The observed variable is defined as being equal to the latent variable whenever the latent variable is above zero and equal to zero otherwise.

$$g_i = \begin{cases} g_i^* & if > 0 \\ 0 & if \ g_i^* \leq 0 \end{cases} \qquad (3)$$

where; is a latent variable

$$g_i = \alpha z_i + \tau_i, \ \ \tau_i N(0, \sigma^2) \qquad (4)$$

If the relationship parameteris estimated by regressing the observedon, the resulting Ordinary Least Squares estimator (OLS) is inconsistent. Maddala (1983) has proven that the likelihood estimator suggested by Tobin (1958) for this model is consistent.

The likelihood function of the model (4) is given by as follows:

$$L = \prod_0 F_i(g_{0i}) \prod_1 F_i(g_i)$$

$$L = \prod_0 [1 - F(z_i\alpha / \sigma)] \prod_i \sigma^{-1} F[(g_i - z_i\alpha) / \sigma] \qquad (5)$$

where f and F are the standard normal density and cumulative distribution functions, respectively. Then we can write the log-likelihood function as:

$$LogL = \sum_0 \log(1 - F(z_i\alpha / \sigma) + \sum_1 \log(\frac{1}{(2\prod \sigma^2)^{1/2}}) - \sum_1 \frac{1}{2\sigma^2}(g_i - \alpha z_i)^2 \qquad (6)$$

The parameters and are estimated by maximizing the log-likelihood function:

$$\begin{cases} \frac{\partial LogL}{\partial \alpha} = -\sum_0 \frac{z_i f(z_i\alpha) / \sigma}{1 - F(z_i\alpha / \sigma)} + \frac{1}{\sigma^2} \sum_1 (g_i - \alpha z_i) z_i = 0 \\ \frac{\partial LogL}{\partial \sigma^2} = \frac{1}{2\sigma^2} \sum_0 \frac{\alpha z_i f(z_i\alpha / \sigma)}{1 - F(z_i\alpha / \sigma)} - \frac{n_i}{2\sigma^2} + \frac{1}{2\sigma^4} \sum_1 (g_i - \alpha z_i)^2 z_i = 0 \end{cases} \qquad (7)$$

The empirical Tobit model

The probability and intensity of technology adoption is assumed to be a function of a complex set of factors. These factors are social and institutional factors that influence the likelihood of a farmer adopting a technology as well as intensifying the adoption. The Tobit regression model was used to determine the effect of membership in agricultural cooperatives on the probability and intensity of improved technologies adoption among smallholder farmers within the cocoa-based farming system. In this study, the dependent variable is the level of adoption (number of technologies adopted by farmers divided by the number of technologies introduced to farmers).

$$Y_i = \beta_0 + \beta_1 AGEHHED + \beta_2 FFEDU + \beta_3 LATEN + \beta_3 LATEN + \beta_4 FAMEXP + \beta_5 HHSIZE + \beta_6 HIEDLABR + \beta_7 MEMBASS + \beta_8 ACCREDIT + \beta_9 GENHHED + \beta_{10} FAMSIZE + \beta_{11} EXTENSN + e_i \quad (8)$$

where,

Y is Adoption level generated from the adoption index (Number of technologies adopted/ Number of technologies introduced).

The definitions of independent variables are: AGEHHED is age of the farmers (years); FFEDU is number of years of formal education (years) ; LATEN is land tenure status (Dummy variable 1= own land, 0= otherwise); FAMEXP is year of farming experience (years); HHSIZE is household size (#); HIEDLABR is hired labour (manday); MEMBASS is membership in agricultural cooperative (dummy variable 0= non-member, 1= member); ACCREDIT is access to credit (1= accessible, 0= inaccessible); GENHHED is gender of house hold head (0= female, 1= male); FAMSIZE is farm size (ha); EXTENSN is extension visit (1= yes, 0= no); e_i is random error term. The inclusion of these independent variables in the model was based on a previous expectation of the variable used and a review of the literature. These independent variables are expected to influence the adoption of improved technologies (Table 2).

RESULTS AND DISCUSSIONS

Socio-economic characteristics of smallholder farmers in cocoa-based farming systems

The probability of adopting any technology is influenced by the socioeconomic features of the respondents (Akinola et al., 2010; Kehinde, 2020). Therefore, Table 3 describes the socio-economic characteristics of the respondents in the study area. The age of farmers is very important in relation to dissemination and adoption of technological innovations. The average age of the respondents in the study area was 53 years. This indicates that an average farmer in the study area is relatively old. This could be attributed to the fact that older people generally stay in the villages to farm and relatively younger people go to cities for education, learning of trade and in search of white-collar jobs. This finding corroborates the expression of Amos (2007); Akinnagbe and Ajayi (2010); Adedeji et al. (2013) that an average cocoa farmer in South west is old. Though the farmers are old, they may likely bear the risk of adopting of new

Table 2

Description of Variables

Variables	Unit	Expected sign	Description
Age	Year	±	Measured in years
Gender	Dummy	±	1= male 0= female
Land Tenure	Dummy	+	1= if farmer owns land 0= otherwise
Household size	Number of persons	±	Measured in number of household members
Hired labour	Dummy	+	1= if farmer hired labour 0= otherwise
Farm size	Hectares	±	Measured in hectares
Education	Years spent in school	±	Measured in years spent in school
Farming experience	Years spent in farming	±	Measured in years spent in farming
Membership in Agricultural Cooperatives	Dummy	+	1= if farmer belongs to cooperative0= otherwise
Access to credit	Dummy	+	1= Access; 0= otherwise
Extension service	Dummy	+	1= Access to extension service; 0= otherwise

technologies (Bello et al., 2012; Nigussie et al., 2017). However, according to Azumah et al. (2018), the age of farmers does not significantly influence agricultural technology adoption. The majority (74%) of the respondents are male. This indicates that male farmers are more active and involved in cocoa production activities in the study area, possibly due to the stress involved in cocoa cultivation, and gender division of labour, in which females only assist in cocoa maintenance, processing, marketing and transportation (Odendo et al., 2009; Mustapha et al., 2012; Oseni and Adam, 2013). About 90 percent of the respondents are married. This reaffirms the fact that cocoa production is primarily a family business run by the farm households in which their respective spouses assist in the farming operation thereby reducing labour cost. The result agrees with Ojo and Jibowo (2008). This study revealed that the majority (80%) of the respondents have a formal education. This implies that the literate farmers are involved in cocoa production in the area of study. This could facilitate the adoption of improved technologies and farming practices. This finding agrees with Alene and Manyong (2007), Uematsu and Mishra (2010), Abdullahi (2011) and Rimawi et al. (2016). The average years of farming experience in the area of study is 29 years. This study revealed that farmers in the study area, have many years of farming experience. This reiterates the fact that the quantum of farming experience asserts influence on adopting improved technologies (Ajewole, 2010). The average size of households in the study area is 10 persons. This implies that the farmers in the study area have a fairly large household which could probably serve as an insurance against short-falls in supply of farm labour. The average size of farms in the study area is 5 hectares. This implies that cocoa production is carried out on small farms in the study area. This supports the findings of Adeogun (2008) who reported that majority of farmers in five cocoa producing states in Nigeria have between one to five hectares of cocoa farm. The conclusion from this finding is that cocoa production takes place on smallholdings. These findings agree with that of Aneani et al. (2012) and Oluyole et al. (2015) that cocoa farmers are predominantly small-scale farmers. About 78 percent of the respondents are visited by extension agents in the last production season. This finding reveals that majority of the respondents have access to extension services. This could facilitate the adoption of improved technologies and farming practices. Membership in agricultural cooperatives is relevant in the adoption decision process. The majority (70%) of the respondents are members of agricultural cooperatives. This implies that the farmers in the area of study had organized

Table 3

Socio-economic Characteristics of Smallholder Farmers in Cocoa-based Farming Systems

Variables	Cocoa-based farmers
Age (years)	52.3(±14.3)
Male (%)	74
Married (%)	90
Formal education (%)	80
Household size (#)	9.7 (±3.2)
Farm size (ha)	5.6(±3.2)
Years of farming experience	29.0(±9.7)
Extension visits (%)	78
Agricultural cooperative (%)	70

themselves into agricultural cooperatives. Membership of agricultural cooperatives allows interactions among farmers in terms of the information dissemination (Akinola, 2008 and Junge et al., 2009; Kehinde et al., 2018). This implies that membership in cooperatives fosters adoption of innovations introduced to the farmers in the study area.

The typology of agricultural cooperatives available in cocoa-based farming system

The types of agricultural cooperatives available in the study area are presented in Figure 1. Four types of agricultural cooperatives were identified in the area of study namely: marketing cooperatives, multipurpose cooperatives, thrift and credit cooperatives, and producers' or farmers' cooperatives. The figure revealed that majority (53%) of the respondents participate in Thrift and credit cooperatives, while a few of the respondents (12%) participate in multipurpose cooperative societies. This supports the findings of Ibitoye (2012) and Baruwa et al. (2016) that the major cooperative societies in the rural areas are marketing cooperatives, farmers' multipurpose cooperatives as well as thrift and credit cooperatives.

Adoption of improved technologies in cocoa-based farming systems

In this study, an adopter is defined as a farmer who invests in any of the improved technologies. Firstly, the respondents were classified into non-adopters of any improved technologies, adopters of improved seed varieties, adopters of fertilizer, adopters of pesticide, adopters of recommended spacing, and adopters of recommended mixed cropping. The classification was done based on which of improved technologies was adopted by an individual farmer. Farmers could be interested in improved production technology package but may not adopt the whole items in the package due to some factors such as insufficient fund, technicality involved, among others. The average level of adoption in the study area was found to be 37 percent. This suggests that the improved technologies introduced to cocoa- based farming systems, have made no appreciable progress in the study area. In the study area, there are some of the respondents that did not adopt any of the improved technologies introduced to the area. They are classified as non-adopters. This could be attributed to ineffective extension service, highly cost effectiveness of the technology, land tenure insecurity among other things (Junge et al., 2009). On the other hand, there are two categories of adopters in the study area (Figure 2). The first categories are the partial adopters (61%). These ones combined adoption of improved seed varieties, pesticide with recommended mixed cropping while the second categories are the full adopters (39%). These ones combined adoption of improved seed varieties, pesticide, recommended mixed cropping, recom-

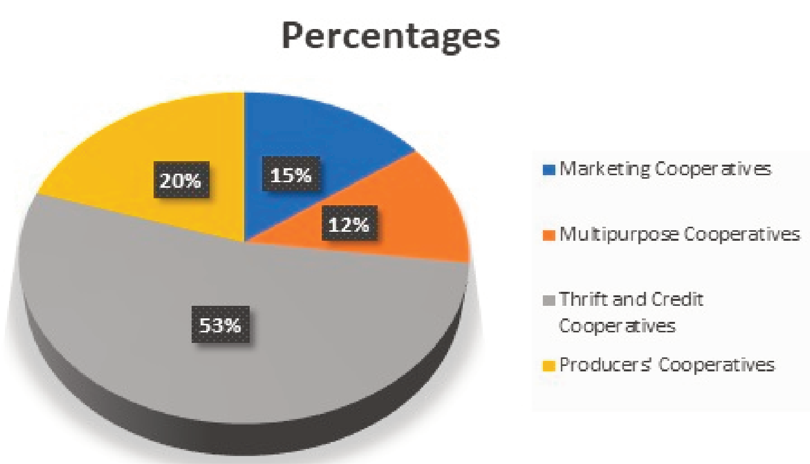

Figure 2. The Typology of Agricultural Cooperatives mended spacing with fertilizer. The classification was done based on the extent of adoption of improved technologies by individual farmers. A farmer is classified as a non-adopter of improved technologies if he did not use or invest in any of improved seed varieties, fertilizer, pesticide, recommended spacing and recommended mixed cropping.

Effect of membership in agricultural cooperatives on rate and intensity of improved technologies adoption among smallholder farmers within cocoa-based farming systems

The dependent variable in the model is the intensity of technology adoption. The intensity of technology adoption is the single dependent variable generated by the adoption index. This study adopted the adoption rate used by Kehinde et al. (2018). The value of the adoption level ranged from 0 to 1. Table 4 shows the results of the estimated Tobit model. The chi-square statistic is statistically significant (LRChi^2 = 44.85; Prob > Chi^2 = 0.000). This justifies the rationale for using the Tobit model. The coefficient of the Tobit model (R^2) was 0.831. This implies that 83.1 percent variation in the adoption level was due to the independent variables considered in the model. The coefficient of gender of the household head has a positive and significant effect on improved technology adoption among farmers with cocoa-based farming system. This implies that male headed households adopt more improved technologies than female headed households. Furthermore, effective contact with male households increased the level of adoption of improved technologies by 0.4 percent. This can be attributed to the fact that male headed households have better access to information and other resources on improved cocoa production technologies. This result agrees with the expectation of the study and previous studies such as Adebiyi and Okunlola (2013); Menale et al. (2012); Chiputwa et al. (2011); Peterman et al. (2010); Quisumbing & Pandolfelli (2010); Datar and Del Carpio (2009) and Abay and Assefa (2004). In a way, this is suggestive of female farmers lagging roles in the adoption of improved technologies. This finding opined that the adoption of improved agricultural technologies by women farmers are constrained by several factors which may include access to modern inputs and technologies, education and land. Household size is a notable proxy for labour availability which influences adoption decisions. Ndiritu et al. (2014) pointed that larger households are more likely to invest in the adoption of labour-intensive sustainable practices. In this study, the coefficient of household size has negative and significant effect on improved technology adoption among farmers within cocoa-based farming system. This implies that smaller households adopt and use improved technologies more than larger fami-

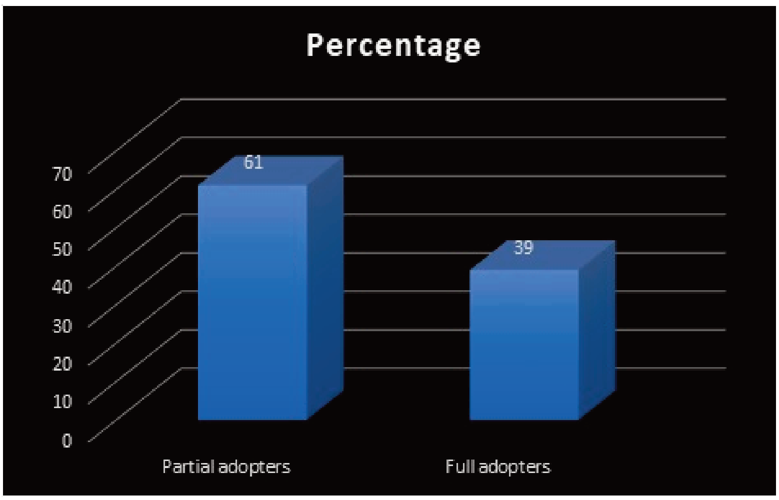

Figure 3. Adoption Typology of Improved Technologies

lies. A further unit of household size reduced the level of adoption of improved technologies by 1.0 percent. This can be attributed to the fact that households with large members may be forced to divert part of their labour force to off-farm activities in an attempt to earn more income in order to ease the consumption pressure imposed by a large family (Tizale, 2007; Yirga, 2007). This outcome is in line with the findings of Akinola et al. (2010) and Idrisa et al. (2012). The coefficient of hired labour has a positive and significant effect on improved technology adoption among farmers with cocoa-based farming system. Furthermore, an additional unit of hired labour increased the level of adoption of improved technologies by 0.3 percent. The reason could be associated to the fact that the family labour is not readily available for farm operations. Therefore, farmers depend on hired labor for farm activities, especially for clearing, weeding and harvesting activities. This finding agrees with the expectation of the study and the outcome of previous studies such as Nchinda et al. (2010). The coefficient of farm size has a positive and significant effect on improved technology adoption among farmers within cocoa-based farming system. The positive coefficient suggests that farm size increases the intensity of improved technologies. An increase in farm size by an additional hectare increased the adoption intensity by 0.7 percent. This could be due to the fact that farm size has bearing on the capacity of farmers to adopt improved technologies and new farm practices. In other words, an increase in farm size could stimulate and enhance better adoption of improved technologies. This agrees with the expectation of the study and the outcome of previous studies such as Adeniyi and Valerie (2010) and Idrisa et al. (2012). The coefficient of extension visit has a significant and positive effect on improved technology adoption among farmers within cocoa-based farming system. This implies that the extension visit increases the level of adoption of improved technologies. The study revealed that an increase in extension visit per unit increased the level of adoption of improved technologies by 0.9 percent . This is because contact with extension agents is seen as a proxy for access to information and it is vital for technology adoption. This agrees with the expectation of the study and the outcome of previous studies such as Beke (2011), Makate et al. (2019) and Kehinde (2020). This is explained by the fact that farmers who have contacts with extension agents are likely to hear about improved technologies and thus have more incentive to adopt them. The coefficient of belonging to an agricultural cooperative has significant and positive effect on improved technology adoption among farmers within cocoa-based farming system. Effective contact with a member of an agricultural cooperative has increased the level of adoption of improved technologies by 10 percent . It can be attributed to the fact that social group allows cross fertilization of ideas among farmers. It also encourages joint purchase of inputs which are later sold to farmers at lower prices. This creates an avenue for awareness of improved agricultural technologies by exposing the farmer to a variety of ideas and also provides access to credit to procure inputs such as fertilizer, improved seeds, herbicides, pesticides and payment for labour required for adoption. This agrees with expectation of the study and outcomes of previous studies such as Akinola et al. (2010) and Wasula (2000).

CONCLUSIONS

This study investigated the effect of membership in agricultural cooperatives on probability and intensity of improved technologies adoption among smallholder farmers within cocoa-based farming systems of Southwestern Nigeria. A multistage sampling procedure was used to obtain data for the study. Data were analysed by using descriptive statistics, adoption index and the Tobit model. There are two categories of adopters in the study area. The categories are partial and full adopters based on the average

Table 4. *Effect of Membership in Agricultural Cooperatives on Rate And Intensity of Improved Technologies Adoption among Smallholder Farmers within Cocoa-Based Farming Systems*

Adoption level	Maximum likelihood estimates	t-stat	Marginal effect
Gender	0.032**	2.05	0.004**
Age	-0.234	-0.76	-0.011
Household size	-0.240***	-3.96	-0.010***
Education	0.044	1.01	0.003
Farming Experience	-0.02	-0.46	-0.001
Farm Size	1.946***	3.66	0.007***
Credit access	-0.549	-0.56	-0.023
Cooperative	1.115***	3.08	0.104***
Land tenure	0.025	0.21	0.006
Hired labour	0.044*	1.93	0.003*
Extension service	0.016**	2.30	0.009**
Constant	0.346**	2.13	
Sigma	0.234	0.10	

LRchi^2= 44.85, Prob> chi^2 = 0.0000, Log likelihood = 72.74 Pseudo R^2= 0.8309, 8 left- censored observations at adoption level=0 192 uncensored observations, 0 right- censored observations. ***p<0.01, **p<0.05, *p<0.1. Figure in parentheses represents t-ratio value.

level of adoption of improved technologies. The improved technologies are not sufficiently accepted in the study area as their level of adoption is still relatively low. Most of the farmers in the sampled population, have organized themselves into agricultural cooperatives. The main channel through which the improved technologies were disseminated to the farmers was agricultural cooperatives. Gender, household size, hired labour, farm size, extension visit and membership in agricultural cooperatives significantly influenced the level of adoption of improved technologies. However, agricultural cooperatives and extension services must be taken into account in an effort to increase the adoption of improved technologies in cocoa-based farming system.

RECOMMENDATIONS

The study concluded that membership in agricultural cooperatives has a significant influence on the level of adoption of improved technologies among farmers in cocoa-based farming systems. Owing to the fact that cooperative societies perform numerous roles (Beyene and Kassie, 2015 and Ogunleye et al., 2020), cocoa-based farming system farmers should be encouraged to form agricultural cooperatives to enable greater social interaction and cross-fertilization of ideas in order to access improved agricultural technologies. In addition, an agricultural development program that ensures efficient and effective training on improved technologies should be established through the synergetic efforts of extension and agricultural cooperative institutions. Government and other developmental agencies should strengthen the capacity of extension agencies to provide efficient educational progammes as well as the capacity of agricultural cooperatives to provide microcredit necessary for greater adoption of improved cocoa production technologies among farmers. Therefore, a simultaneous provision of cooperative membership and access to extension would have far more significant potentials to increase the adoption rate of improved technologies as well as its intensity. That is, extension services should be packaged with cooperative services in order to accelerate the adoption of improved technologies in cocoa-based farming systems.

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CONFLICT OF INTEREST

The authors have not declared any conflict of interest.

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