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REGULAR ARTICLE

DETERMINANTS OF THE AWARENESS AND USE OF ELECTRONIC INFORMATION SYSTEMS: EVIDENCE FROM FARMERS IN BURKINA FASO

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ABSTRACT

The use of information systems using mobile phone support is important in agriculture in terms of generating efficiencies in production and improving farmers' incomes. In Burkina Faso, despite the increasing spread of a wide variety of agricultural information via mobile phones since the 2000s, few farmers have adopted such an electronic information system. This research aims to empirically analyse the factors that influence the awareness and use of electronic information systems by producers. Primary data were collected from a sample of 210 grain producers and analysed using descriptive statistics and a logit sequential model. Descriptive statistics indicated that farmers interviewed had an unmet need for timely access to relevant, reliable, continuously available, and unfragmented information. The econometric results suggest that a high number of years of schooling for the head of household, regular contact with extension agents and technical assistance from market information systems (MIS) management structures influence awareness of electronic information systems. With regard to the actual use of the services offered by these information systems, the presence of educated members in the household, the size of the farm, the perceived relevance of non-commercial benefits derived from the information disseminated and access to agricultural financing appear as significant determinants. These results have required more targeted public policies.

Keywords: adoption, electronic information system, agricultural information, farmers, Burkina Faso
JEL: Q10, Q12, Q13, Q16

INTRODUCTION

Market information systems (MIS) are one of the most significant innovations revolutionizing information technology in the agricultural sector (**Diekmann *et al.*, 2009; Minten al., 2012; Subervie and Galtier, 2012; Tadesse and Bahiigwa, 2015; Beza *et al.*, 2018**). These systems are devices intended to collect, process and disseminate information on the situation and dynamics of agricultural markets to economic agents (public and, especially, private actors, such as agricultural producers, traders and consumers). The information disseminated is supposed to reinforce the transparency of markets and help the actors in their decisions about production and marketing. MIS generally disseminate information using different types of support: rural radios, billboards, print media (newspapers, newsletters or gazettes), the internet (website or mailing list) and mobile phones.

In recent years, information systems using mobile phone support have continued to grow in most developing countries (**Aker and Mbiti, 2010; Tadesse and Bahiigwa, 2015; Beza *et al.*, 2018**). Qualified as electronic information systems, they are increasingly instruments for promoting agricultural development in developing countries. Due to their high level of access, broad reach, good adoption rate and real-time interaction, mobile phones offer effective solutions to rural communication problems (**Msoffe and Ngulube, 2016).** They effectively reduce the distance between individuals and institutions, facilitating the sharing of information and knowledge. Mobile phones are a global communication channel for rural communities, expanding the impact of established rural media, such as rural radio, and helping to make local content accessible to rural people and making rural services more efficient and profitable (**Aker and Mbiti, 2010; Msoffe and Ngulube, 2016**). Although the use of electronic information systems in agriculture is in its infancy, recent studies have indeed shown the potential of these information systems in agriculture. **Kidole** (**2015**) reports that these information systems have increased the gross profits of 90% of farmers in Moshi District in Tanzania. In the case of Ethiopia (**Tadesse and Bahiigwa, 2015**; **Beza et al. 2018**), it is of note that the information provided by mobile phones has allowed farmers to increase their yields. In Uganda, access to business information through electronic information systems has increased farmers' incomes by 16.5% to 36% (**Marke, 2014**). **Subervie and Galtier** (**2014**) show that in Ghana, farmers who have benefited from continuous information on market prices via mobile phone have been able to improve their average selling price of 12.7% for maize and 9.7% for groundnuts.

While the services offered by electronic information systems are important for generating efficiencies in production and improving farmers' incomes, they are not always adopted by farmers (**Tadesse and Bahiigwa,**

2015; Duchaufour *et al.*, 2016; Beza et *al.*, 2018). The reasons seem subtle and go beyond the rational decisions traditionally advocated in the economic approach. In this sense, it is no longer the objective characteristics of the environment, as indicated in the standard economic approach, which are supposed to define the behaviour of the economic agent, but the type of knowledge held by the agent. But the individual can only have an incomplete and subjective knowledge of the environment in which he acts. This hypothesis reflects the fact that the individual is not looking for optimal solutions to solve the problems he encounters, but that he is content with accessible and satisfactory solutions (**Bromley, 2006; 2008**). In the case of agricultural innovations, **Chambers *et al.*** (**1994**) show that the farmer does not think in terms of adoption or rejection as researchers do. He seeks to know this novelty, its features, its advantages and disadvantages, then forms his own opinion of the new idea and determines the attitude to be observed: either adoption or rejection. In addition to understanding the premises of awareness of the services provided by electronic information systems, it is desirable to understand what would increase its degree of use by farmers. Often, public authorities have focused on stimulating awareness, the idea being that increased use will follow (**Fall et *al.*, 2015**).

In Burkina Faso, the literature on the adoption of agricultural technologies is rich in theoretical concepts, and targeted studies on different types of technologies are abundant. However, minimal research has examined the factors affecting adoption of electronic information systems by rural actors. This study attempts to fill this gap by attempting to empirically analyse the factors that influence the awareness and use of services offered to grain farmers through these information systems. The grain farmers were chosen in view of the crucial importance of cereal crops in agriculture in Burkina Faso. Cereals occupy more than 75% of the annual area cultivated in Burkina Faso (**MARHASA, 2016**). A better understanding of the factors affecting the adoption of electronic information systems by farmers offers new opportunities for agricultural extension actors, agricultural professionals, information specialists and MIS management structures to design the most effective strategies for disseminating agricultural information.

The originality of this study exists at two levels. First, to our knowledge, there is no work on the adoption of electronic information systems by farmers in Burkina Faso. Thus, our work can provide an interesting basis for comparison with studies conducted in other parts of the world. Second, we highlight that the factors influencing the awareness of the services offered by electronic information systems are not the same as those influencing the use of these systems.

The following section provides a review of the literature that shows the challenge of farmers' access to information via the mobile phone and highlights the main theoretical determinants underpinning our analysis of the adoption of electronic information systems. The third section presents the methodological approach used. The method of collecting primary data from farmers and the Logit Sequential model used to analyse these data are exposed. The results of statistical analyses and the determinants of the awareness and use of electronic information systems are presented and discussed in the fourth section. Finally, we conclude by reflecting on the public policies to be implemented to increase the adoption of these information systems.

LITERATURE OVERVIEW

This section provides a review of the literature that shows the challenge of farmers' access to information via the mobile phone and highlights the main theoretical determinants underpinning our analysis of the adoption of electronic information systems.

The challenge of access to information

From an economic point of view, the performance of agricultural markets depends in particular on the quality of the flow of information between the various actors in the agricultural sectors (**Aker, 2010; Duchaufour et *al.*, 2016**). Access to market information enables users to make better decisions about investing, producing, selling or buying. In fact, economic agents (traders, producers, public authorities) have information about agricultural markets (prices, quantities, quality) that is often incomplete, and sometimes false. In addition, asymmetries of information are common (**De Janvry et *al.*, 1991; Bullock et *al.*, 2002; World Bank, 2009; Aker, 2010; Rashid and Minot, 2010; Siyao, 2012**). Market information systems would help reduce information asymmetries and transaction costs (searches for information, verification of validity, etc.). MIS would lead to improved individual decisions and a rebalancing of forces between different actors.

The function of MIS is to collect information on markets and to disseminate this information to public (State) and private (producers, traders, consumers).

The first generation of MIS was managed by centralized public services that collated and processed grain price data and disseminated it in several media such as national radio, television, newspapers and news bulletins (**Duchaufour et *al.*, 2016**). Most of them were funded by projects. Limited in terms of flexibility and innovation capacity, they had mixed results (**Intereseaux, 2008**). This system had several shortcomings, including delays in transmission, errors, few markets included, etc. Towards the end of the 1990s, many advances led to the emergence of the second generation of MIS. The appearance of mobile phones and the spread of the internet have offered many opportunities. Previously, the transmission of price data from the collection point to the central unit could take several days. Currently the information in "real time" can be delivered in a few hours. This has allowed for expanding product categories as well as considering different quality standards. Data are no longer price-restricted, they also include other market-related information (local trade flows, imports / exports, sellers 'or buyers' contacts), production (meteorology, technical advice) or policy measures. (standards, regulations). The possibilities of real interactivity and contacts between buyers and sellers can be transmitted by individual offers. The use of mobile phones has increased to the point that this has attracted private entrepreneurs, who have set up market information services. Mobile telephones offer the possibility of interactivity, which represents an essential evolution: "push" systems, in which a standard information package is distributed to all users, can be replaced by "pull" systems, in which each user can choose the information they need from a wide range (either from individual requests or from individualized subscription systems). In addition, this interactivity allows MIS managers to control the information required and then adjust the service provided to meet the needs of users.

In Burkina Faso, both public information systems (MIS cereals of SONAGESS) and private information systems (MIS Afrique Verte of the NGO Afrique Verte, MIS CIC-B of the Interprofessional Committee of Cereals of Burkina) are registered. There are also sub-regional and international information systems (MIS RESIMAO, ESOKO). Private information systems are the most used. Farmers receive the information by SMS (Short Message Service). MIS management structures establish memoranda of understanding or information distribution contracts with national radio and television. There are two types of radio that are used by the agricultural world in Burkina Faso, namely: The National Radio, which covers a large part of the territory, and the community radios which are local radio stations that broadcast information in rural areas. MIS management structures use national television and private commercial televisions. The information is in French and in national languages (16 national languages are concerned). The broadcast is done at fixed times. For private SIMs, the content and the time of diffusion of the information are variable according to the types of contracts signed with radio or TV. Several MIS devices use the mobile phone. In recent years, electronic information systems have raised hopes in Burkina Faso because of the strong penetration of mobile telephony in rural areas. **INSD** (**2015**) indicates that 56% of the rural population of Burkina Faso uses a mobile phone. In parallel with the explosion of mobile telephones, there is a very low level of commercial information among farmers (**INSD, 2015**). The challenge of access to information from electronic information systems is enormous, and it seems important to reflect on the possibilities of increasing access to agricultural information through such a system.

Determinants of the adoption of a market information system

The adoption of a technology is a process characterized by a certain level of heterogeneity, where it is very useful to understand the variables/factors that affect the process. A striking empirical observation regarding the adoption of new technologies is that there is usually a significant gap between the discovery of a new technology and its adoption. Early work by **Schumpeter** (**1934**) and **Mansfield** (**1968**) attributed the delay in adopting new technology to uncertainty about the nature of technological change. Studies on the adoption of technology indicate that the decision to use an innovation is a process in which different factors interact. **Rogers** (**1995**) pointed out that innovations perceived by farmers as having a greater relative advantage, compatibility with past experience and farmers' needs, a clear observability of results, an ease to be experienced and a reduced complexity would be adopted faster than other innovations.

Another set of factors that play an important role in the adoption process is related to the characteristics of the adopters. Researchers have found that men far outnumber women in the use of information technology (**Ma et *al.*, 2018**). In several studies, education and age have also had positive effects on the adoption of electronic information systems (**Velandia *et al.*, 2009; Birba and Diagne, 2012; Carrer *et al.*, 2017; Beza et *al.*, 2018; Ma et *al.*, 2018**). According to these studies, the level of education has increased farmers' ability to process information, make decisions and acquire new information technologies. For age, there appeared two possible contradictory effects. On the one hand, older farmers were likely to have greater knowledge of the benefits associated with new information technology and find it easier to use this technology. On the other hand, older farmers were more conservative and less likely to use new technologies. It is therefore difficult to hypothesize for this variable. In addition, a number of researchers (**Hollenstein, 2004; Carrer *et al.*, 2017; Mothobi and Grzybowski, 2017**) have shown that economic and financial factors, such as the farmer's income level and the cost of access to information technology, were important factors in the farmers' decision to adopt the technology. These researchers have shown that low income and a high cost of technology are barriers to the adoption of information systems. Another important factor that has emerged in the use of new information technologies is the size of the farm (**Velandia *et al.*, 2009; Tadesse and Bahiigwa, 2015; Mbanda-obura et *al.*, 2017**). Farmers with a large agricultural area were more likely to adopt new information technologies than farmers who cultivated a small area. It has also appeared in the literature that the perceived relevance of non-commercial benefits offered by technology has increased the likelihood of its adoption (**Diekmann *et al.*, 2009; Msoffe and Ngulube, 2016; Laraichi and Hammani, 2018**). Other authors have also shown that those with limited previous experience in using short message service (SMS) were less likely to adopt electronic information systems (**Zhou *et al.*, 2010**). Finally, some studies have found that institutional factors, such as agricultural extension and access to agricultural credit, positively affected the adoption of information technologies (**De Janvry *et al.*, 2015; Mbanda-obura *et al.*, 2017; Carrer *et al.*, 2017**).

DATA AND METHODS

This section presents the methodological approach used. The method of collecting primary data from farmers and the Logit Sequential model used to analyse these data are exposed.

Study areas and data collection

Our sample comes from a field survey conducted between July and December 2017 by the International Cabinet of Economic, Environmental, Social and Spatial Expertise. This research office is a private structure that has existed since 2012 and has conducted several surveys and studies for the benefit of private institutions in Africa. It is based in Ouagadougou. The purpose of the survey was to collect primary data to build the capacity of grain producers for better market access. These data were collected from 210 farm managers, as well as heads of households. A semistructured survey questionnaire was prepared, and the investigators were trained for the occasion. Cabinet selected interviewers who spoke local languages from the areas studied in order to ensure that the respondents understood the questions. Since the Cabinet survey was a multipurpose survey, the questionnaire was organized around several areas of investigation, including the socioeconomic factors of farmers and the institutional and technological characteristics of farming. We worked at the farm level collecting information about the farm manager and the farm household. A two-stage random sampling procedure was adopted to obtain the total sample size. First, three rural areas were selected on the basis of the importance of cereal production (sorghum, millet and maize) and the presence of MIS management organizations. Sorghum, millet and maize are the main dry cereals produced and consumed in Burkina Faso. The selected study areas were Boulsa (North Central region), Koudougou (West Central region) and Toma (Boucle du Mouhoun region). In each zone, there are also representations of MIS management structures that disseminate information to producers. This distribution is valuable, and the cost depends on the diversity of information requested. In these areas, some farm managers benefit from information via their mobile phones, thanks to the NGO grant. Second, 70 farm managers were randomly selected from each of the three zones. These farmers were identified using the list made available by agricultural extension officers, and farmers' organizations helped to confirm it. The criteria for confirming information included transparency, confidentiality rules and the validity of the information provided. Regarding transparency, a protocol describing the survey methodology and the survey guide is available and accessible. The database is available. The research team consisted of several academics. Reconciling the information held by the agricultural extension services with that provided by the farmer organizations made it possible to judge the overall validity of the information available. The survey approach also respected the data confidentiality rules.

Specification of the analysis model

Several authors (**Buis, 2010; Fall *et al.*, 2015; Gichuki and Mulu-Mutuku, 2018**) describe the adoption of an innovation as a process that goes through two stages or transitions. First, the individual seeks to know the service and its utility. This "awareness" phase is the starting point for any adoption process. The second phase is "use", in which the individual actually uses the services offered by the electronic information system. As part of our work, the decision tree comes in the form of a two-level choice problem. The division of the choices into subsamples is easily feasible, insofar as one can naturally distinguish the farmers who are aware the electronic information system and those who are not aware of them on the one hand, and, on the other hand, those who use it, and those who do not use it. Thus, if farmers are not aware of a service offered by this system, then they will not use it. On the other hand, if farmers are made aware, then they will have to choose between using it or not. The hierarchical structure of our model can be reproduced in the form of the decision tree (Figure 1).

Figure 1 shows a hypothetical process, which is to be described using a sequential logit model (**Buis, 2011; Fall *et al.*, 2015; Gichuki and Mulu-Mutuku, 2018**). The sequential logit model consists of separate logistic regression for each step or decision on the subsample that is "at risk" of making that decision. The adoption process of electronic information systems is thus described by a sequential model with two transitions: awareness and use.

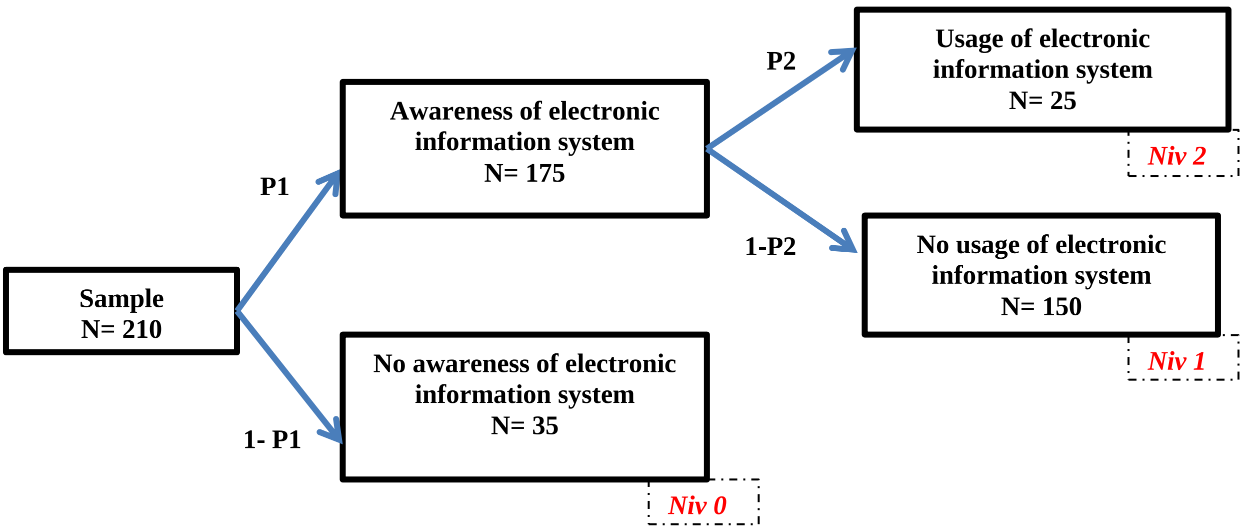

Figure 1. The adoption process of electronic information systems
Source: Own elaboration

The sequential logit model models the probabilities of passing these transitions. This is done by estimating a logistic regression for each transition on the sub-sample that is at risk, as in Eq. (1).

$$p_{ki} = \frac{\exp(X_{ki}\beta_k)}{1+\exp(X_{ki}\beta_k)} \quad if\ P_{k-1,i} = 1 \qquad (1)$$

where X_{ki} represents the characteristics of farmer i for step k, and β_k is a parameter vector to be estimated for step k.

There are three levels in this process. At each level reached by the farmers, they are assigned a number, *niv*. For farmers who are not aware of the electronic information system, level 0 is assigned. For those who are aware of it but do not use it, level 1 is assigned, and for those who have used it, level 2 is assigned. The average level achieved for each farmer, given their socioeconomic characteristics, is determined by Eq. 2.

$$E(niv) = (1 - p_1)l_0 + p_1(1 - p_2)l_1 + p_1p_2l_2 \qquad (2)$$

where l_0, l_1 and l_2 are the farmer's gain at levels 0, 1 and 2, respectively.

The variation in a characteristic of the farmer affects the transition probability and is calculated by the formula (Eq. 3).

$$\frac{\partial E(niv)}{X_{ki}} = \{ 1 \times \hat{p}_{1i}(1 - \hat{p}_{1i}) \times [(1 - \hat{p}_2)l_1 + \hat{p}_2l_2 - l_0] \}\beta_1 + \{ \hat{p}_{1i} \times \hat{p}_{2i}(1 - \hat{p}_{2i}) \times [l_2 - l_1]\}\beta_2 \qquad (3)$$

The marginal effect of the farmer's characteristics on the average level of the farmer is a weighted sum of the different levels (Eq. 4).

$$\frac{\partial E(niv)}{X_{ki}} = \omega_1\beta_1 + \omega_2\beta_2 \qquad (4)$$

The contribution of each level to reaching the adoption level of the technology is $\omega_i\beta_i$. The weights $\omega_i$correspond to the risk of not passing the level × the variance of the indicator variable, whether or not the level × the farmer's gain passes if he passes the level. Thus, for the first level, the risk is [1], the variance is $[p_{1i}(1 - p_{1i})]$, and the gain if the farmer passes the first level is $[(1 - p_2)l_1 + p_2l_2 - l_0]$. For the second level, the risk is $[p_{1i}]$, the variance is $[p_{2i}(1 - p_{2i})]$, and the gain if the farmer passes the second level is $[l_2 - l_1]$.

RESULTS AND DISCUSSION

Three categories of results are highlighted. First, the demographic, socio-economic and institutional characteristics of the farmers who participated in this study are presented. The information most frequently cited by farmers as being important and necessary, their assessment of the information they receive and their level of ownership of the access to information equipment are then exposed. The third result category deals with the impact of the farmer's socio-economic and institutional characteristics (sex, age, school years, household education, contact extension, years of mobile phone, farm size, technical assistance, perceived relevance of non-commercial benefits derived from information, access to agricultural financing) on the decision to adopt the electronic information system.

Descriptive Analysis

The descriptive statistics in Table 1 show that there is a significant gap between the proportion of farm managers who are aware of electronic information systems and the proportion that use them. Thus, despite the good awareness of these systems (82.93%), few farm managers (11.84%) use them. The question asked to farmers to create the "awareness" variable is this*: when you think about agricultural market information systems, what supports come to mind?* Table 1 presents the descriptive statistics of the explanatory variables of the sequential logit model. Table 1 also indicates that 90.05% of the sample is male. Such a result reflects the low proportion of farms headed by women. This scenario is understandable since, in rural areas, women can become heads of farms only when there is no longer a man of working age in the household. The average number of years of schooling for a farm manager is 1.86 years. This reflects the low level of schooling in rural Burkina Faso (**INSD, 2015**). However, 85.03% of farmers surveyed have at least one student in their household. The survey results also highlight that the average age of farm managers is 38 years, with a minimum of 17 years and a maximum of 86 years. There are, therefore, young farmers as well as relatively old farmers. In addition, the survey results reveal that almost all farm managers (92.41%) are members of a professional organization. These organizations have the stated objectives of safeguarding and promoting the interests of all their members. The level of involvement of farmers in professional organizations can be seen as an indicator of their openness to the environment and information. In addition, the survey results show that the average size of farms is 3.31 ha. Farm size varies from 1.5 ha to 14 ha. The sample is therefore composed of farmers with very small agricultural sizes than those with relatively large areas. Such a disparity in farm size is observed at the national level (**INSD, 2017**). In addition, the average number of years of use of a mobile phone by farm managers is 2.28 years, with a minimum of 1 year and a maximum of 13 years. There are, therefore, relatively new mobile phone users, as well as farmers who have more experience in using these devices. The survey also shows that only 14.53% of farmers had access to agricultural finance, which came in the form of a credit or agricultural subsidy. In addition, 7.25% of farmers received technical assistance from MIS management structures. Finally, 14.79% of the farmers interviewed considered the information disseminated from electronic information systems to be relevant.

Table 1: Variables considered in the econometric analysis model

Variable	Description	% or mean	SD
Awareness	1 if the farmer is aware of the electronic information system and 0 if not	82.93%	0.443
Usage	1 if the farmer uses the electronic information system to make his decisions and 0 otherwise	11.84%	0.325
Sex	1 if the farmer is male and 0 if not	90.05%	0.266
Age	Age of the farmer in years	38	11.378
School years	Number of years of schooling of the farmer	1.86	1.94
household Education	1 if the household has an educated member outside the farm head and 0 otherwise	85.03%	0.424
Organization	1 if the farmer is a member of a professional organization and 0 otherwise	92.41%	0.500
Extension contact	1 if the farmer has contact with agricultural extension services and 0 if not	92.41%	0.446
Technical assistance	1 if the farmer has received technical visits from the MIS management structures and 0 if not	7.25%	0.684
Years of using mobile phone	Number of years of mobile phone use by the farmer	2.28	0.627
Farm size	Size of the farm	3.31	3.151
Access to agricultural financing	1 if the farmer has access to agricultural finance and 0 if not	17.53%	0.810
Relevant information	1 if the farmer considers relevant the non-commercial benefits offered by the electronic information system and 0 otherwise.	12.79%	0.369

The information needs of farmers

Before attempting to understand the determinants of the adoption of electronic information systems, it is necessary to understand the type of information considered important and necessary for the decision-making of managers. The survey results shed light on these information needs. As shown in Figure 2, the most important information needs relate to the availability and conditions of use of inputs (seeds, fertilizers, plant protection products) and agricultural equipment (85%), market prices (wholesale and retail) (80%), the list of input suppliers (76%), market accessibility conditions (76%) and existing potential sources of financing (70%). Similarly, half of the farm managers in the sample (50%) mention the need for meteorological information and information on conservation techniques for agricultural products. Finally, information on market prices of imported agricultural products, transport opportunities and agricultural regulations are cited by 20%, 15% and 12% of farm managers, respectively. These results highlight that farmers have information needs related to the main constraints they face in the production, conservation and marketing of agricultural products. It is important to note that all of this information is available from MIS management structures.

In addition, the results of the survey reveal a high rate of nonsatisfaction about access to information among farmers (Figure 3). All the farmers interviewed feel that they do not receive the information they need. The reasons given are that information is not received in a timely manner (79%), is not relevant (75%), is fragmented (62%) or is unreliable (60%). The low frequency of information received and the difficult analysis of this information are also indicated by 50% of the farmers interviewed. When the farmer refers to information not received in a timely manner, he emphasizes the long delays in the information chain. However, when he refers to the low frequency of the information received, he emphasizes the low regularity and low updating of the data. Indeed, information can be obtained regularly by the farmer (e.g. the price variation) but not in time that would allow him to negotiate better his selling price. Similarly, information can be given at a given time, which can be useful for the farmer at this point in time (for example, the demand for agricultural products in different markets at harvest) but not regularly updated (e.g. lack of the same information in the dry season).

In summary, farm managers express the need for timely access to relevant, reliable and unfragmented information. We can notice that electronic information systems have the potential to meet such a need.

Analysis of access to information equipment

To access information, some tools are needed. It seemed useful to us to evaluate the level of possession of these tools by the farmers surveyed. The possession of a radio in the household is reported by the majority of farmers surveyed (97%) (Figure 4). Almost all farmers (94%) also reported that at least one household member has a mobile phone, 12% of farmers own a TV, and only 4% say they connect to the internet.

It appears that mobile phones as well as radio can be an appropriate channel for transmitting information to farmers.

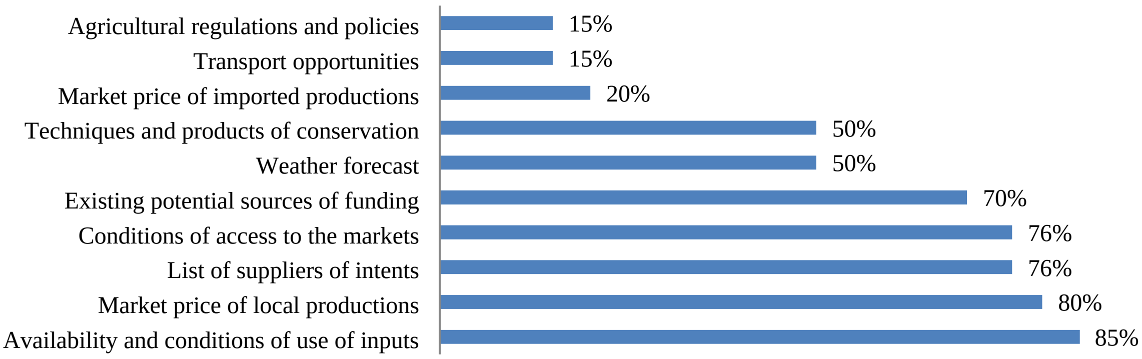

Figure 2. Information needs of farm managers

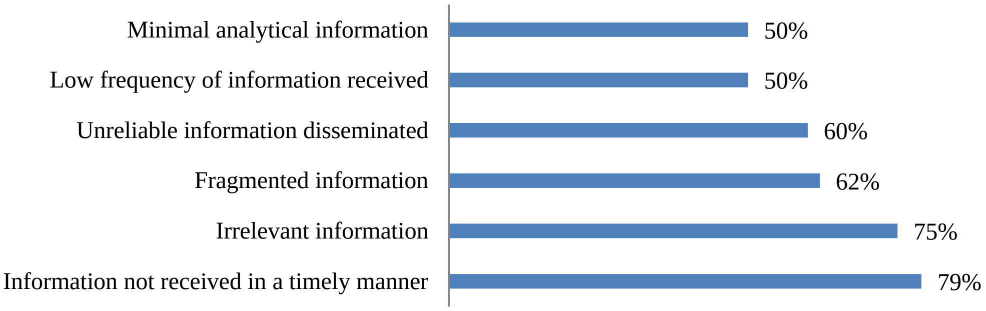

Figure 3. Reasons for nonsatisfaction with the information received by farmers

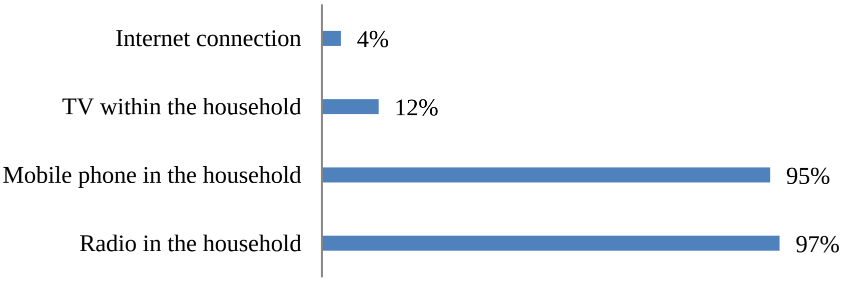

Figure 4. Access to information tools.

Econometric results

Table 2 presents the results of the logit sequential model estimation. In addition to the estimated parameters, the marginal effects of each independent variable on the dependent variable of the respective model are also presented. These effects show the variation in the dependent variable in response to small changes in an independent variable, all else remaining equal. The maximum likelihood ratio test rejects the null hypothesis that all coefficients are statistically equal to zero. The variable "membership in an agricultural professional organization" was removed from the estimate because it had a very strong correlation with the variable "agricultural extension". This strong correlation is understandable to the extent that farmers join farmers' organizations in order to access extension services and credit facilities. The variable "sex" was also removed from the estimate of the probability of using electronic information systems because no female farm manager in the sample used the services of these systems.

Determinants of Awareness of Electronic Information Systems

The results show that the most marked differences are apparent in the number of years of schooling of farm manager, the contacts with agricultural extension agents and the technical assistance of the agents of MIS management structures.

The results of this study indicate that farm managers with higher years of schooling are more likely to be aware of the services offered by electronic information systems. This result is in line with previous work (**Velandia *et al.*, 2009; Carrer *et al.*, 2017; Aklin *et al.*, 2018; Beza *et al.*, 2018; Ma *et al.*, 2018**).

Table 2. Estimation of the determinants of awareness and use of the services offered by electronic information systems (marginal effects and standard errors in parentheses)

Variable	Awareness of an electronic information system	Use of an electronic information system
Sex	0.350 (1.202)	-
Age	-0.089 (0.132)	0.127 (0.112)
Age squared	0.001 (0.001)	0.001 (0.001)
School years	0.093 (0.127)**	0.447 -(0.169)
Household education	0.027 (0.210)	0.058 (0.206)**
Extension contact	0.289 (1.055) **	0.720 (0.582)
Years of using mobile phone	0.198 (0.396)	0.029 (0.462)
Farm size	0.030 (0.078)	0.061 (0.123)**
Technical assistance	0.529 (0.937) ***	0.203 (0.860)
Relevant information	-	0.204 (0.709)**
Access to agricultural financing	0.236 (0.069)	0.259 (0.112)***
Constant	1.563 (2.896) ***	6.189 (3.226)**
N	210	
Log likewood	-426.37	

Note: * $p<0.1$; ** $p<0.05$; *** $p<0.01$

The marginal effect on the number of years of schooling shows that each year of schooling increases the probability of awareness of the electronic information system by 9.32% (this value is calculated for the mean values of the number of years of schooling). The major task of education is to actively involve individuals in self-education process and encourage their independence in learning process (**Sagitova, 2014**). It helps to develop flexible and adaptable thinking. In addition, technical assistance has a large marginal effect value (0.529), so probability of awareness of the electronic information system for a farmer from technical assistance is 52.9% higher, than average. The significant effect of this variable is also observed in **Carrer *et al.*** (**2017**), who explained that farm visits made by agents of MIS management structures increased farmers' awareness of the characteristics of electronic technologies, thereby enhancing farmers' confidence in these technologies. Equally important, contacts with agricultural extension services increase the probability of awareness of electronic information services. The estimated marginal effect of this variable shows that the probability of awareness of electronic information systems for a farmer through agricultural extension is 28.9% higher than the average. This result is in line with previous studies (**Tey *et al.*, 2017; Mbanda-obura *et al.*, 2017**), showing that such contacts are an important tool for information transfer that allows farmers to better know the availability and functionality of new technologies.

However, having experience using mobile phones does not bring awareness of electronic information services. The variable "Age" included in the model in linear and quadratic forms also does not affect the probability of awareness of electronic information systems. Similarly, variables such as sex, farm size and access to agricultural finance do not appear to be significant determinants in the early stage of the adoption of electronic information services.

Determinants of the use of the electronic information system

In the second stage of the adoption process (i.e., the actual use of the electronic information system), the presence of educated members in the household, the size of the farm, the perceived relevance of non-commercial benefits derived from information and access to financing appear to be significant determinants.

In contrast to previous work, the number of years of schooling of the head of household does not significantly influence the probability of the use of electronic information systems. However, having educated members within the household, which was not important for awareness of electronic information systems, now appears as a variable that significantly explains the use of these information systems. This result is in line with the findings of **Tadesse and Bahiigwa** (**2015**), who indicated that the presence of an educated child or spouse in the household allowed the household to adopt a new technology. The education of a member of the household can therefore generate positive externalities within the household by allowing it to adopt the electronic information system. This result is understandable to the extent that head-of-household farmers, when out of school, tend to consult with a member of their household for reading written messages or letters. Farm size, which was not a determinant of awareness, also appears to be a significant explanatory factor of use. This result is consistent with the findings of **Velandia *et al.*** (2009) and **Hollenstein** (**2004**). The probability of using the electronic information system is proportionately higher for large-scale farms, demonstrating the advantage of scale for the adoption of these information systems. The marginal effect of this variable on the probability of use is 6.1%. Under the assumption that a physical farm size corresponds to a high farm income, we can also assume that interest in the use of electronic information systems corresponds with high levels of agricultural income. Moreover, as expected, the question of the relevance of the information disseminated seems to arise for farmers. The perceived relevance of non-commercial benefits derived from information increases the probability of farmers using electronic information systems by 20.4% compared to the average. Our analysis has indeed confirmed that the farmer will adopt the electronic information system when the information disseminated is relevant to confer a certain social status or prestige in the community. This conclusion is in line with the results of several studies which show that some farmers are ready to adopt a technology if they find interests in terms of hierarchical position, safeguarding jobs, legitimacy and authority, power and recognition, or prestige and privilege (**Msoffe and Ngulube, 2016, Waren *et al.*, 2016, Taylor and Bhasme, 2018**).In this sense, when relevant information is disseminated to farmers, they will be encouraged to use this information because of the noneconomic benefits they obtain from using this information. The other key factor that has a significant effect on the effective use of electronic information services is access to agricultural finance. When the farm manager has access to a credit or agricultural subsidy, his probability of using electronic information systems is 25.9% higher than average. Similar findings can be found in **Carrer *et al.*** (**2017**) who indicate that access to finance reduces farmers' budget constraints and facilitates investment in new technologies.

Given that farmers, on average, have few years of schooling, it was anticipated that agricultural extension and technical assistance from MIS management structures would influence the use of electronic information systems, but this is not the case in our estimation. This result implies that farmers will not simply adopt the technology because they have regular contact with agricultural extension agents or because they receive technical assistance from the MIS management structures. Neither age nor experience in the use of mobile phones is significantly associated with the use of electronic information systems.

CONCLUSIONS

This research helped to understand the factors that influence awareness of electronic information systems and their use by grain producers in Burkina Faso. The econometric results suggest that the number of years of schooling of farm managers, contacts with the agricultural extension agents and the technical assistance of the MIS management structures make farmers more aware of electronic information systems. With regard to the actual use of the services offered by these information systems, the presence of educated child or spouse in the household, a large sized farm, the perceived relevance of non-commercial benefits derived from the information disseminated and access to funding appear to be significant and positive determinants. This article clearly shows that the determinants of awareness of electronic information systems differ from those of the actual use of the services offered by these systems. This conclusion has strong implications in terms of public policies.

It is suggested that the different public and private actors work together to ensure that sufficient attention is given to each of the elements that enhance the awareness and use of the electronic information system. This requires that governments, MIS management structures, information providers and village leaders play a key role in this regard. The management structures of MIS will have to seek to better understand the specific information needs of different farmers before embarking on information dissemination activities. It is therefore necessary for these structures to carry out regular assessments of information needs and to ensure that the information disseminated is context specific. They will also need to ensure that capacity building programs are designed and implemented and that information resources are available

Finally, since rural infrastructure is vital for the provision of information services to farmers, it is important that governments give priority to this field. Improving rural infrastructure would enable the electronic information system to be fully exploited. The lack of reliable energy sources due to low electricity coverage and the lack of other basic services such as transport, make ICT connectivity in rural areas particularly difficult. Improving such infrastructure would allow the electronic information system to be fully exploited. Rural areas of Burkina Faso continue to be sparsely covered and are not considered as a viable business case by telecommunication operators. Recent growth of teledensity in urban areas, fuelled by mobile technology, has meant that the digital gap between rural and urban areas has widened. The quality of rural infrastructure projects is, however, crucial for economic development. We agree with the **World Bank** (**2005**) that effective public sector action is required, to establish a regulatory and legal framework that enables the rise of a vibrant innovative competitive private telecommunications and ICT services sector, and to institute selective efficient and transparent public subsidies with high social payoff but low financial returns.

The results of our research are of great importance to policymakers, agricultural specialists, researchers and NGOs undertaking studies on the use of the electronic information system in rural areas of developing countries. The study may also be useful to the private sector, other information professionals and farmers in the areas selected in this research and Burkina Faso as a whole.

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REGULAR ARTICLE

MARKET PARTICIPATION INTENSITY EFFECT ON PRODUCTIVITY OF SMALLHOLDER COWPEA FARMERS: EVIDENCE FROM THE NORTHERN REGION OF GHANA

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ABSTRACT

This paper explored the effect of market participation intensity on productivity of smallholder cowpea producers in the Northern Region of Ghana. A cross-sectional primary data of 183 cowpea producers was sampled from three communities in each of four selected districts in the region. The Instrumental Variable (IV) regression model using the 2SLS estimator was employed to estimate the causal effect of intensity of market participation on productivity. The results revealed that market participation intensity, measured as the proportion of output sold is endogenous in the cowpea on-farm productivity model. This finding implies that policy measures that lower transaction costs will significantly boost smallholder cowpea productivity by empowering farmers to intensify their participation in the market. Additionally, policies tailored towards increasing farmers' farm size, removing barriers in accessing and cultivation of improved varieties of cowpea seed as well as diversification of agricultural production activities should be promoted. Furthermore, opportunities created to enable these farmers upgrade themselves through the formal educational system will in the long run enable them to raise their on-farm cowpea productivity level through the adoption of productivity enhancing technologies.

Keywords: productivity, intensity of market participation, cowpea, endogeneity, Ghana
JEL: Q13, Q15, Q18, R53, R58

INTRODUCTION

Ghana's agriculture is smallholder dominated, with these farmers dwelling predominantly in rural communities, and close to 90% of their land holdings are less than 2 hectares in size and they are also resource poor **(MoFA -SRID, 2016).** Agricultural policy frameworks and strategies such as the Food and Agriculture Sector Development Policy (FASDEP I &II), Ghana Shared Growth and Development Agenda (GSGDA) and the Medium Term Agriculture Sector Investment Plan (METASIP) have been accented to and developed by the government of Ghana with the view to spurring accelerated growth and productivity in the sector. These policies are also geared towards increased participation in the market by smallholder farmers to ensure food security **(Abu, *et al*. 2016).** Following from these policies, successive governments have thus over the years, with the support of multiple NGOs, launched various projects that stimulate agribusiness agendas and link farmers to markets **(Akpalu *et al*. 2015; Abdulai and Huffman, 2000; MoFA, 2011)**. Government's current flagship agricultural programme, "Planting for Food and Jobs (PFJ)" aims at targeting interventions that dovetail into a transformative goal of intensifying the market orientation of the smallholder farming sector. The programme is therefore designed to provide farmers with marketing support and inputs, including high yielding seed varieties and targeting better transportation infrastructure in crop growing areas.

Smallholder producer's choice to intensify participation in agricultural markets is considered an essential determinants of household agricultural productivity, level of commercialisation and kind of crop diversification practised on-farm **(Asfaw *et al*. 2012; Lipper *et al*. 2010; Lipper *et al*. 2006; Smale, 2006)**. In general, arguments for why intensity of participation in the market by smallholder farmers is essential to improving household productivity and wellbeing of rural dwellers have been compartmentalised into two **(Barrett, 2008)**. The first is that, it gives farmers the leverage to concentrate on producing goods in which they are experienced in producing, and trading the generated surplus for other desirable goods and services for which they possess no such comparative advantage. The last is that, it enables them capture greater economies of scale and technology adoption which, collectively, leads to a more rapid total factor productivity growth **(Asfaw *et al*. 2012; Barrett, 2008)**. Improving access to markets for smallholder farm households is a potential pathway to enhancing their productivity levels.

Akpalu *et al*. (2017) also emphasise the need for market participation resulting from higher land productivity and the vice versa driving the agricultural transformation agenda. This according to them has the ability to raise the incomes of subsistence, low input, low productivity farming systems practised by farmers in the Northern Region in particular and Ghana as a whole. To this end, boosting agricultural productivity and intensifying market participation of smallholder cowpea producers is considered the most promising strategies to achieving pro-poor growth, rural development and agricultural transformation in the Northern Region of Ghana.

The Northern Region of Ghana has been identified as one of the poorly endowed regions and the per capita income of the people fall far below the national average **(Marchetta, 2011)**. **IFAD-IFPRI (2011)** and **Yirzagla *et al.* (2016)** identify factors such as land holding size, fewer marketed crops and location for the variation in market participation intensity rates and crop production in Ghana. They further argued that production and intensity of market participation in some selected commodities such as cowpea by smallholder farmers tends to be lowest in Northern Region of Ghana. Though an agrarian region, it does not have adequate market infrastructure compared to other regions. Participation in food crop production is the dominant agricultural activity in the region accounting for 70%-85% of agricultural output.

Cowpea is an important food crop produced and consumed by most households in the region. It is the second most important legume crop in terms of production capacity or volume and area under cultivation after groundnut, but with higher domestic consumption levels than groundnut. **MoFA-SRID (2016)** and **Yirzagla *et al*. (2016)**, report that average farm-level productivity on farm area basis is minimal, ranging between 0.6 Mt/ha to 1.25 Mt/ha representing an achieved yield of 50%. These statistic reveal that there is the potential for yield to increase to between 1.2 Mt/ha to 2.5 Mt/ha if the appropriate production and market participation conditions are available and accessible to these smallholder producers. Mean annual production growth rates have also witnessed a declining fortune in recent years. From 2004-2009, the estimated mean annual production growth rate averaged over the six-year period was 3.62%. This six-year growth rate figure however saw a sharp decline from the 2010-2015 production period to -3.77% **(MoFA-SRID, 2016)**. With these low production volume and yield, smallholder farmers are therefore unable to obtain high marketable surpluses to enable them participate in the market, take advantage of economies of scale and increase land productivity.

Smallholder cowpea producers in the Northern Region of Ghana have not been able to out-scale production and intensified their participation in the market of the commodity which has a global market share of approximately $1.13-2.81 billion **(AATF, 2012)** to improve their livelihoods. This state of affairs has arisen as a result of poor logistical infrastructure rendering the transportation of agricultural produce difficult leading to increased transaction cost in the marketing process of cowpea. The resultant effect is that smallholder farmers' ability to commercialise and intensify production have been constrained culminating in low productivity and low incomes by farmers **(Abdulai and Huffman, 2000; Akpalu *et al*. 2015; Langyintuo *et al*. 2003; World Bank, 2011)**. That intensified market participation influences the productivity level of smallholder farmers in Ghana have not been fully and exhaustively studied and explored. It is against this backdrop of the uncertain effect of market participation intensity on productivity of smallholder cowpea farmers that this study is undertaken to contribute to the existing literature on market participation intensity linkage with productivity.

DATA AND METHODS

Sampling procedure and data collection methods

The main population for the study comprised of smallholder farmers (farmers who cultivate at most 2 ha of cowpea during the study period). All cowpea farmers who produced on more than 2 ha land holding of cowpea are excluded from the sample and therefore not considered as a smallholding. A cowpea farmer for the purpose of this study is a farmer who produces cowpea as a mono-crop or as an intercrop.

A multi-stage sampling as well as key informants interview approaches were adopted for the study. The multi-stage procedure is a three-stage; clustered, purposive and randomised sampling procedure. The three stages involve selection of the districts, communities, and lastly, selection of cowpea producers and non-producers. In the first clustering stage, four farming districts were purposively selected based on the fact that they are among the top ten cowpea producing districts in the Northern Region of Ghana. In the second stage, twelve (12) communities, three (3) from each district were selected purposively based on their production potential of cowpea. This purposive selection was done in broad discussions with district officers of MoFA. This was to prevent a random sample of communities where cowpea is not intensively produced. The third and final stage involves randomly selecting respondents from the communities chosen in the second stage. It is envisaged that identification of smallholder cowpea farmers will be difficult. Therefore, in order to overcome this challenge, a communal place (a place where farmers normally congregate as it is the case in most farming communities in the Northern Region) was used as the reference point for preparing a list of smallholder farmers. Sixty (60) cowpea producers were interviewed from the 12 communities selected in each of the four (4) districts to make up a total sample size of two hundred and forty (240). Out of this figure, one hundred and eighty-three (183) of the sampled farmers interviewed through the administration of semi-structured questionnaire were identified to intensify their participation in the market by offering some proportion of their cowpea harvest for sale.

Conceptual and Analytical Frameworks

Economists have promoted intensity of market participation as an integral part in attaining a comparative advantage in production. The fundamental argument is that smallholder farmers are able to raise their income levels by producing that which offers the highest returns to the primary factors of production namely land and labour. These smallholder farmers then use the cash or income generated to purchase household consumption items, in order not to be constrained to produce all the different goods required for consumption **(Timmer, 1997; Govereh and Jayne, 2003)** premised on their intensity of market participation. Though this concept of comparative advantage is well noted in economic theory under the assumption of frictionless markets, the reality is that the process of intensity of market participation is impeded by high transaction costs that is associated with the food marketing system **(Govereh and Jayne, 2003)**.

Based on the concept established above, a direct synergistic relationship or linkage therefore exists between intensity of market participation and productivity of food crops, and in this case cowpea. The following potential pathway by which intensity of market participation may affect cowpea (crop) productivity can therefore be deduced: smallholder farmers' intensity of market participation in the cowpea market will enable them to acquire resources and inputs that otherwise would not be available for cowpea production and other food crop production enterprises since most smallholder farmers in the northern region of Ghana are multiple crop producers. Notably, under conditions of limited access to farm credit, smallholder farmers' ability to intensify market production may depend on their participation in cowpea production in particular and other food crop production ventures in general. For instance, **Strasberg (1997)**, noted that under credit and input market failures in northern Mozambique, participation in cotton out-grower production ventures was the basic avenue of obtaining cash inputs for use in cotton and other food production activities. In the Central Province of Kenya, smallholders participating in coffee production obtained through their coffee co-operatives access to credit, inputs, extension services and equipment for use on coffee production as well as on other food crops. The coffee co-operatives' unambiguous support of members' food crop production activities was based on the basis that this would raise their ability to sustainably and profitably participate in coffee production, which would in turn provide longer term benefits to the company (**Govereh *et al*. 1999)**.

The analytical framework identified the factors that influenced productivity while controlling for intensity of market participation as an endogenous variable. Based on the theory of market participation, smallholders decide whether to be cowpea producers or non-producers while also deciding either to be market participants or non-market participants. Conditional on being a market participant, the intensity of participation or proportion of output sold is determined. This intensity of market participation is hypothesised to influence farmers' cowpea crop productivity level. From the productivity literature, factors such as household characteristics, resource endowments (private and public assets and service variables)/institutional factors, transactions costs, location variables, and market price are all hypothesised to influence productivity **(Rios *et al*. 2009; Govereh and Jayne, 2003)**.

Based on insights from previous literature and economic theory, factors that affect productivity are generally composed of household characteristics, resource endowments (defined as private and public assets and service variables)/institutional factors, transactions costs, location variables, and market prices **(Gyau *et al.* 2016; Rios *et al*. 2009; Govereh and Jayne, 2003)**. Household characteristics are denoted by five controlled variables, which are age, gender educational level, dependency ratio and farm size. Age is expected to have positive association with cowpea productivity. The hypothesis is that older farmers are expected to be more experienced in productivity enhancing decision making. Male smallholder farmers are perceived to have more access to productive assets such as land, labour and capital which increases their production capabilities and hence, a positive relationship is expected with productivity. Educational attainment enhances smallholder farmers' prospects of obtaining and processing market information accurately **(Makhura, *et al*. 2001)** as well as adoption of productivity enhancing techniques and thus a positive relationship is expected. These three socio-economic variables have also been identified to have a positive effect on productivity in empirical studies by **(Barrett, 2008; Ouma and Abdulai, 2009; Weinberger, 2001).** Dependency ratio is also expected to positively influence productivity since high availability of active labour force in the household will be channelled into supporting productivity enhancing activities. According to **Olwande and Mathenge (2012)**, farm size may have indirect positive impacts on productivity. Larger farm size enables farmers to create marketable surpluses, surmount cash constraints in situation where land can be used as collateral for credit, and permit farmers to embrace improved technologies that increase productivity. Therefore positive relationship is expected between farm size and productivity.

Transaction costs variables are the key intensity market participation determinants which also affect productivity **(Rios *et al*. 2009)**. These variables according to **Key *et al*. (2000)** are mostly not observable in survey data and are therefore represented with proxy variables hypothesised to be observable factors that represent them. Two of these variables were used as candidate instruments for intensity of market participation which is a continuous variable measured as proportion of output sold. The hypothesis is that, the only pathway through which these instrumental variables affect productivity is only through smallholder farmers' level of market participation intensity. The instrumental variables include ownership of means of transportation and proximity to all-weather good road. The plausibility of each of these instrumental variable as stated before relates to the extent to which it is associated with farmers' productivity through their market participation intensity and not any production relationship directly **(Rios *et al.* 2009).** However, distance to nearest market is expected to negatively affect productivity. The hypothesis is that, the longer the distance to the nearest market, the lesser the selling orientation of the smallholder farmer will be and hence the lower will be their productivity. Access to market information will potentially reduce the problem of information asymmetry and accelerate the rate of productivity decision making.

Resource endowment factors of production measure the wealth of smallholder farmers. Possession of productive assets (private and public assets) and services are mentioned as important factors of agricultural productivity **(Rios *et al.* 2017; Schultz, 1964; Kirui, 2013)**. Private and public assets variables and service variables used as controlled variables in the model include total household income, labour, possession of own land by the smallholder farmer, value of owned livestock, access to credit, and access to extension services. Income obtained from trading activities influences productivity since farmers are able to overcome the problem of cash constraints and devote some of this income to the purchase of farm inputs to enhance productivity. Therefore the effect of total income on productivity is expected to be indefinite. The number of mandays (labour) expended on cowpea production activities can potentially positively raise the productivity level of farmers. The intuition here is that, farmers spend quality time in working on their farms and this ensure timely control of weed and insect pest that are likely to attack their crops. Having secured rights to land are mostly promoted as an avenue for generating incentives for farmers to invest in technologies and practices that engender land conservation and raise productivity in the long-run **(Pingali and Rosegrant, 1995; Rios *et al.* 2009)**. Ownership of livestock, access to credit and extension services are all potential variables that can positively influence productivity **(Minten and Barrett, 2008)**. It is however expected that the more visits the extension service provider pays to the farmers, the more likely the farmer would produce and increase productivity. Access to improved cowpea variety for cultivation and access to tractor for ploughing are also expected to positively influence productivity.

District market price of cowpea output is expected to positively affect smallholder farmers' productivity level as theorised by **Key *et al*. (2000)** and **Alene *et al*. (2008)**. This variable measures the selling price of cowpea in the market. The lagged value of selling price was not used based on the cross-sectional nature of the dataset. Unobserved location-specific effects were controlled using the districts as dummy variables. These dummies were incorporated in the models as controlled variables to address dissimilarities in the overall disparities in economic and social conditions of the various communities. These location-specific disparities refer to infrastructure, inaccessibility, resource endowment, production potential and farming conditions across districts. The relationships the results from these dummies revealed are to be explained by the specific characteristics and attributes of each of the location following **Mmbando *et al*. (2015)**. The dummy for Tolon district was used as a reference and was left out of the model to avoid the dummy variable trap. Tolon was used as the reference variable because it was identified to be the largest producer of cowpea with smallholder farmers obtaining higher level of productivity.

Econometric Estimation

Intensity of market participation is potentially endogenous in the cowpea food crop productivity model and therefore in order to overcome the problem of endogeneity, the Instrumental Variable (IV) approach using the Two-Stage Least Squares (2SLS) estimator was employed. The alternative estimation procedure was to employ the Ordinary Least Squares (OLS). But this approach would not resolve the endogeneity problem and the estimators would be biased and inconsistent. The instrumental variable approach allows for the estimation of coefficients that are consistent and free from asymptotic bias from omitted variables as well as measurement errors **(Angrist and Krueger, 2001)**. The foremost Economist to employ the procedure was P.G. Wright. **Wright (1928)** first discussed the issue in the seminal application of instrumental variables in estimating the elasticities of supply and demand for flaxseed, the source of linseed oil. Following from that, several other Economists such as **Goldberger (1972)**, **Morgan (1990)** and **Bowden and Turkington (1984)** have all applied the instrumental variable procedure in diverse econometric analyses. According to **Angrist and Krueger, (2001)**, if there is more than one valid instrument, the coefficient of interest can be estimated by two-stage least squares. While two-stage least squares and other instrumental variables estimators are consistent and unbiased, the drawback of the approach is that it can also result in biased and inconsistent estimates if invalid or weak instruments are used and the model incorrectly specified leading to under or over identification issues. These estimation challenges were addressed in this study by conducting the Durbin-Wu-Hausman test statistics and the joint significance test of instruments validity. The Instrumental Variable 2SLS model can be specified as in Eq. 1.

$$Y_i = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 \tilde{\theta}_i + \varepsilon_{1i}$$
$$\theta_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \nu_{1i} \qquad (1)$$

Where Y_i is productivity measured as gross value of cowpea output produced per hectare for cowpea production for smallholder farmer i, $\alpha_0, \alpha_1, \alpha_2, \beta_0, \beta_1, \beta_2$ and are unknown parameter estimates of interest, X_i is a vector of common exogenous regressor variables hypothesised to be correlated with cowpea crop productivity, $\tilde{\theta}_i$ is the predicted values of proportion of output sold used to measure the intensity of market participation, θ_i is the intensity of market participation itself that is potentially endogenous in the productivity model, ε_i is an error term X_{2i} is a vector of instruments for intensity of market participation and ν_i is an error term. Where the $E(\varepsilon_{1i}) = 0$ and $cov(\varepsilon_{1i}, \nu_{1i}) = 0$. The empirical model specification for the Instrumental Variable 2SLS estimation is stated as in Eq. 2, while table 1 presents a vivid description of the variables used in the estimation. STATA version 15 was used in analysing the data.

$$\begin{aligned} Productivity &= \beta_0 + \beta_1 IMP + \beta_2 Age + \beta_3 Gender \\ &+ \beta_4 Depratio + \beta_5 Educy + \beta_6 Fsize + \beta_7 Distmkt \\ &+ \beta_8 Ami + \beta_9 Total\_income + \beta_{10} Labour \\ &+ \beta_{11} Livestock + \beta_{12} Cowvar + \beta_{13} Tracplough \\ &+ \beta_{14} Credit \\ &+ \beta_{15} Ext + \beta_{16} Cowpea\_price + \beta_{17} Tolon + \\ &\beta_{18} Yendi + \beta_{19} Mion + \beta_{20} Kum + \varepsilon_i \end{aligned} \qquad (2)$$

Table 1: Description of dependent, endogenous and explanatory variables included in the model

Variable	Description/Measurement	
Dependent Variable		
Productivity	Natural log of gross value of cowpea produced per hectare, GHS/ha	
Endogenous Variable		
Intensity of Market Participation (IMP)	Proportion of cowpea output sold in kilograms	
Explanatory Variables		Sign
Household Characteristics		
Age	Age of respondent/Continuous variable	+
Gender	Gender /Dummy (1=Male, 0=Female)	+
Dependency ratio	Ratio of inactive to active labour/continuous	+
Education	Educational level of respondent in years	+
Farm size	Total farm size in hectares	+
Transaction Cost Variables		
Distance to market	Distance to nearest market in kilometres	-
Access to market information	Access to market information/Dummy(1=Yes, 0 = No)	+
Resource Endowments/Institutional Factors		
Private Assets		
Total household income	Natural log of total household farm income in Ghana Cedis	+/-
Labour	Farm labour use in mandays	+
Land ownership type	Landownership type/Dummy (1=Own land, 0= No)	+
Livestock	Value of owned livestock in Ghana Cedis	+
Public Assets and Services		
Access to improved cowpea seed	Access to improved cowpea seed/Dummy (1=Yes, 0=No)	+
Access to tractor for ploughing	Access to tractor services for ploughing /Dummy (1=Yes, 0=No)	+
Access to credit	Access to credit/Dummy (1=Yes, 0=No)	+
Access to extension services	Access to extension service/Dummy(1=Yes, 0=No)	+
Market Price		
Selling price of cowpea	Natural log of selling price per bowl of cowpea in Ghana Cedis	+
Location Variables		
Tolon district	Household in Tolon/Dummy (1=Yes, 0=Otherwise)	+/-
Kumbungu district	Household in Kumbungu/Dummy (1=Yes, 0=No)	+/-
Mion district	Household in Mion/Dummy(1=Yes, 0=Otherwise)	+/-
Yendi district	Household in Yendi/Dummy(1=Yes, 0=Otherwise)	+/-

RESULTS AND DISCUSSION

Factors influencing smallholder cowpea productivity

Before proceeding to estimate the factors influencing smallholder cowpea productivity in the Northern Region of Ghana, I present a brief descriptive summary of the aggregated productivity levels and proportion of output sold in the markets by the sampled smallholder farmers in the four districts. The results are displayed in Table 3 below. For Tolon and Mion districts, the higher the level of productivity the greater the proportion of output sold in the markets. But the same conclusion cannot be made between Kumbungu and Yendi. Though farmers in Kumbungu had lower level of productivity than Yendi, they however had greater marketable surpluses than their counterparts from Yendi. What this means is that cowpea producers in Yendi produce more for household consumption than for sell in the markets and therefore having higher level of productivity does not necessary mean increased level of intensity of participation for cowpea farmers in Yendi.

Table 2: Cowpea productivity and proportion of output sold per sampled district

District	Productivity	Output produced	Output sold	Proportion sold
Tolon	97132.80	35544	16977	47.76
Kumbungu	36142.80	13785	8058	58.45
Mion	51610.80	18699	12984	69.44
Yendi	39278.40	14313	5952	41.58
Total	224164.80	82341	43971	

Source: Author's own computation

The Instrumental Variable 2SLS regression model was first checked for possible presence of multicollinearity. The estimated VIF value was less than the critical value of 10 **(Gujarati and Porter, 2009; Shiferaw** *et al*. **2008)**, confirming that multicollinearity was not a problem. The productivity model was also tested for heteroskedasticity by using the Breusch–Pagan/Cook–Weisberg test. The result indicated no presence of heteroskedasticity, since the calculated χ^2 value of (1.45) was smaller than the tabulated χ^2 value (3.84) at the 5%

significance level and one degree of freedom.

The overall test of possible endogeneity of (intensity of market participation) proportion of output sold in the productivity model produced a Durbin (score) χ^2 (1) = 11.7937, p-value = 0.0006 and Wu-Hausman F (1,218) =11.2662, p-value = 0.0009 and they are both highly significant and therefore the null hypothesis that all the variables are exogenous is rejected (that is, the first-stage OLS and 2SLS estimates are not identical). This therefore implies that proportion of output sold is highly endogenous in the productivity model and therefore endogeneity needed to be controlled for in the estimation process. Additionally, the first-stage Ordinary Least Squares (OLS) regression estimates of F-statistic for joint significance of instruments is also highly significant, F (2, 218) =144.88, p-value = 0.0000 and the Partial R-squared value (0.550 or 55%) is far greater than the critical nominal 5% Wald test values and therefore the null hypothesis that the instruments used for intensity of market participation (possession of own means of transportation and proximity to good road network) are weak is also rejected. The Instrumental Variable 2SLS regression estimates are displayed in Table 3.

The results indicate that, proportion of harvest sold, instrumented by the intensity of market participation variables is a significant correlate of productivity while controlling for other exogenous variables. Statistically, an increase in the proportion of output sold by a kilogram per cedi of sales, causes productivity or the gross value of cowpea production per hectare to increase by approximately 72% while controlling for other significant exogenous variables or holding all other variables constant. This finding is consistent with that of **Rios *et al*. (2009)** and **Strasberg *et al.* (1999)** who identified a positive relationship between productivity and intensity of market participation.

Age of the smallholder farmer was found to be significant but rather had a decreasing or negative effect on productivity. This could be explained by the fact that, proportion of older people in the sample who might not be innovation inclined unlike the younger producers are less productive. This supports the finding of **Boughton *et al.* (2007)** who estimated a negative coefficient for maize productivity in Mozambique. Other literatures that support a negative estimated coefficient for age are **Siziba *et al*. (2011), Olwande and Mathenge (2012), Rios *et al.* (2009)** and **Reyes *et al*. (2012)**.

The educational attainment of the household head, measured as the number of years spent in school had a positive effect on productivity and statistically significant at 5%. This means that a higher level of education of the smallholder farmer is associated with a higher level of productivity. This observation is consistent with the findings of **Makhura *et al*. (2001), Enete and Igbokwe (2009), Randela *et al.* (2008), Southworth and Johnston (1967), Schultz (1945)** and **Ofori (1973)** who argued that education will endow the household with better production and managerial skills which could lead to increased productivity and higher output.

Farm size had the expected significantly positive effect on cowpea productivity. The result indicates that the larger the farm size per capita, the more it allowed the smallholder farmer to raise their productivity level. This result is in line with **Rios *et al*. (2009)** who found that Tanzania and Vietnamese farmers with larger land per worker are more productive.

The value of livestock owned by a smallholder farmer was also found to have a significantly positive relationship with cowpea productivity and significant at 1%. This finding suggests that cowpea farmers with diversified agricultural productions are likely to raise their productivity levels in order to maximise income from the sale of cowpea or maximise output for consumption in the unlikely event that their livestock do not attract good market or when they are not ready for sale. The result was found to be consistent with the findings by **Minten and Barrett (2008)** and **Rios *et al*. (2009)** who found similar relationship between livestock owned and crop productivity in Madagascar and Vietnam respectively.

Access to improved cowpea variety was also found to have the expected sign and significant at the 5% level of significance. The result indicates that cowpea farmers who had access to cowpea variety for cultivation had approximately 40% higher level of productivity than farmers who had no access to improved cowpea variety for cultivation holding all other variables constant. The result was found to be consistent with **Strasberg *et al.* (1999)** who found similar relationship between hybrid seed cultivation per acre and food crop productivity in Kenya.

As expected, access to credit was also found to depict a positive relationship with productivity and significant at the 1% level of significance. This result indicates that for farmers who had access to credit, their productivity level is approximately 8% higher than those who had no access to credit for farming. This finding suggests that access to credit is pivotal in achieving higher productivity levels of cowpea in the Northern Region.

The prevailing district level selling price of cowpea grain was also found to possess the expected coefficient and significant at the 1% level of significance. The result indicates that for every cedi (GHS) increase in the selling price of cowpea harvest per kilogramme, farmers' level of productivity is expected to increase by approximately 8%.

With regard to the location of smallholder producers, the coefficient for the variable indicating a smallholder producer located in the Mion district is statistically significant and negatively related to cowpea productivity as compared to a smallholder located in the Tolon district (reference district) showing an approximately 63% lower level of productivity. Mion district is characterised by poor infrastructure with remote communities from a well-developed agricultural research station unlike Tolon where the Savannah Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) is located. Similarly, Kumbungu district also had a statistically significant relationship with productivity with cowpea producers in that district having about 86% level of productivity relative to Tolon. This may be due to the fact that it is relatively a new district with inadequate infrastructure that directly contributes to and promotes productivity

Table 3: Instrumental variable 2SLS regression estimates of productivity with endogenous intensity of market participation

Variable	Coefficient	t-Statistics
Intensity of Market Participation		
Proportion of sales	0.717** (0.875)	2.49
Household Characteristics		
Age	-0.006* (0.005)	-1.78
Gender	-0.061 (0.200)	-0.30
Dependency ratio	0.008 (0.011)	0.67
Education	0.006** (0.012)	2.52
Farm size	0.407** 0.210)	1.94
Transaction Cost Variables		
Distance to market	0.009 (0.014)	0.64
Access to market information	0.118 (0.187)	0.63
Resource Endowments/Institutional Factors		
Total household income	-0.183 (0.199)	-0.92
Labour	-0.013 (0.012)	-1.06
Value of livestock owned	0.001*** (0.000)	3.92
Access to improved cowpea seed	0.407** (0.210)	1.95
Access to tractor services for ploughing	0.037 (0.132)	0.28
Access to credit	0.078*** (0.026)	2.95
Access to extension services	0.010 (0.119)	0.08
Market Price Variable		
Selling price of cowpea	0.078** (0.026)	2.95
Tolon district	reference	
Yendi district	-0.493 (0.423)	-1.16
Mion district	-0.626*** (0.167)	-3.74
Kumbungu district	-0.857*** (0.292)	-2.94
Constant	3.745*** (0.859)	4.36
Breusch-Pagan / Cook-Weisberg test for heteroscedasticity		
χ^2 (1) = 0.12		
Prob > χ^2 = 0.7250		

Source: Author's own computation

Notes: Robust standard error in parentheses. *, ** and *** represent significance at 10%, 5%, and 1% level, respectively. Dependent variable is the natural log of gross value of output produced per hectare.

CONCLUSIONS

Though cowpea is a food security crop in Ghana, land productivity has been low in the Northern Region of the country which happens to be the highest producer of the commodity. To address this low productivity phenomenon among smallholder cowpea producers, conducive marketing environment needed to be created to enable smallholder farmers intensify their market participation activities. This study examined the factors that affect productivity of cowpea while controlling for the endogeneity of intensity of market participation in the estimation process. The appropriate estimation tests were performed to ensure that the assumptions underlying the instrumental variable regression using the Two-Stage Least Squares estimator employed for the analysis are satisfied. The empirical results confirm the endogeneity of intensity of market participation and was therefore instrumented. Other significant exogenous variables that influence productivity of cowpea include educational level of the smallholder farmer, farm size cultivated, value of livestock owned and access to and cultivation of improved cowpea seed. Formulation of policies to ensure lower transaction costs among smallholder farmers will intensify their market participation activities and hence accelerate the promotion of pro-poor growth among smallholder cowpea producers in the Northern Region of Ghana since this will affect their productivity directly and result in higher incomes. Productivity promoting policies should also be designed to encompass formal educational training for farmers, easy access to inputs, as well as agricultural diversification.

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REGULAR ARTICLE

FARMERS' DECISIONS AND DETERMINANTS OF CROP ROTATIONS WITH LUPIN: THE CASE OF WEST AMHARA REGION, ETHIOPIA

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ABSTRACT

Using lupin as a break crop and for soil fertility improvement is one of the practices to enhance productivity and improve soil fertility in Ethiopian conditions. However, the use of this practice by smallholder farmers is limited. Therefore, the major objective of this study was to empirically examine factors influencing farmers' decision to allocate land for lupin crop production as a break crop in North Western Amhara Region of Ethiopia. In this study, stratified sampling procedure was used to select 253 sample households from four Districts (137 household who use lupin in their crop rotations and 116 that do not). The required data were collected using interviews with a structured questionnaire. Logistic regression analysis was used to identify factors influencing farmers' decision to allocate land for lupin production as a break crop. The results of the logit regression analysis indicate that family size, total farmland holdings and contacts with extension workers were the most important factors influencing the decision of the farmer to practice crop rotation with lupin. Hence, emphasis should be given to improve the human capital through training and providing extension service to bring farmers' awareness to practice improved technologies and best indigenous knowledge.

Keywords: Lupin; Crop rotation; Determinants; Logit; Ethiopia
JEL: C13, C25, D13

INTRODUCTION

Ethiopia's socio-economic feature is predominantly rural and agriculture is a key driver of the country's long-term growth and food security. About 85% of the population is in rural parts of the country and agriculture directly supports 83 percent of the population, constitutes 41 percent of Gross Domestic Product (GDP), and 90 percent of export value (**EEA, 2012**). However, complex and widespread poverty, food insecurity, low productivity, famine and degradation of natural resources are among the challenges facing the country (**David *et al.*, 2011**).

Traditional mixed crop livestock production system is practiced by subsistence farmers, focusing on household food security. Ethiopia is rich in its livestock resources with 59.5 million cattle, 30.70 million sheep, 30.20 million goats, 2.16 million horses, 8.44 million donkeys, 0.41 million mules, and about 1.21 million camels in the sedentary areas of the country (**CSA, 2017**). However, the productivity and reproductive efficiency is very low. On the other hand, the demand for livestock products is increasing due to population growth, urbanization and relative improvement of the economy.

According to the Ethiopian livestock master plan (**LMP, 2014**), if no investment is made in raising livestock productivity, in the year 2028 there will be a deficit of 42% and 23% in meat and milk (respectively) in the country due to exploding demand. In the mixed crop livestock production system, the most limiting nutrient in livestock feed is protein. Moreover, concentrated feed supplements are either inaccessible or too expensive for most Ethiopian smallholder farmers. Hence homegrown protein supplements like lupin are very important options to solve the burden of livestock feed supplement in the country beside its importance for market and soil fertility improvement being as a precursor crop for major crops like teff, wheat, maize and others.

According to **IFPRI (2010)**, Ethiopia also faces a wide set of soil fertility issues that require approaches that go beyond the application of chemical fertilizers, the only practice applied at scale to date. Moreover, acidity of the soil (covering over 40 percent of the country), significantly depleted organic matter due to widespread use of biomass as fuel, exhausted macro and micro-nutrients, and reduction of soil physical properties are among the core constraints to agricultural productivity and sustainability in Ethiopia. The problem is particularly serious in the western part of the Amhara region. The population growth rate (2.6%) in the country appears to be greater than the agricultural production rate (2.3%)

contributing to the food insecurity and environmental degradation (**Bachewe, *et al*, 2015; Getachew and Ranjan, 2012**).

One way to tackle this problem is to adopt scientific, cost effective and environmentally friendly production methods such as crop rotation. Crop rotation can be defined as growing crops in a planned sequence on the same field. The principle is to grow annual crops on a different piece of land each year, ensuring that they do not return to the same spot for at least 2 years. Crop rotation has many agronomic, economics and environmental benefits. It improves soil structure with higher levels of organic matter and better water provision resulting in higher yields in the long-term (**EU DGE, 2012**). It creates a more balanced nutrient cycle at the field level and helps farmers to use fewer inputs to maintain nutrient availability that results in lowering costs and increasing profit margins. Lupin species are particular effective in raising soil fertility through symbiotic nitrogen fixation and mobilization of soil phosphorus (**Peoples, *et al*, 2009a; Lambers *et al*, 2013**). Rotation also provides an important break in the disease cycle of crops (**Kirkegaard *et al*., 2008**). Break crop benefits provided by narrow-leafed lupin were detectable up to the third cereal crop after lupin (**Seymour *et al*., 2012**).

Despite these clear benefits, most of farmers in the study districts do not utilize this practice effectively. Considering this fact, this study tried to look factors that affect farmers' decision to adopt crop rotation practice with lupin in the study areas. Knowledge of the extent and causes of such factors will guide policy makers to help increase of agricultural production by designing more effective and efficient institutional support service.

DATA AND METHODS

The Study Area

Four districts namely, Machakel, Sekela (in East Gojam), South Achefer (in West Gojam) and Dera (in South Gondar) were selected because these districts have potential for lupin production as they have acidic and brown clay soil and farmers have experience in using lupin as a break crop for rotation (Figure 1).

Method of Sampling

A multistage sampling procedure was used to select farmers for the survey. The survey was focused on four districts and ten kebeles (Kebeles represent the lowest administrative unit in the Ethiopia). A total of 253 households were randomly selected and identified as adopters (those farmers practicing crop rotation with lupin) or non-adopters of lupin in their crop rotations. Farmers differed in their experience of crop rotation with lupin. Hence, in this study, those farmers typically having more than one field that practiced crop rotation with lupin for two and more consecutive years were considered as adopters and otherwise considered as non-adopters. The sample size for the study was determined based on **Kothari (2004)** (Eq. 1).

$$n = \frac{Z^2 pqN}{e^2(N-1)+Z^2 pq} \quad (1)$$

Where: *n* is the desired sample size, *Z* is the inverse of the standard cumulative distribution that corresponds to the level of confidence with the value of 1.96. p is the estimated proportion of an attribute present in the population and $q = 1-p$. N is the size of the total population from which the sample is drawn. Assuming large population but the variability is not known in the proportion about the inputs use, *p*=0.5 is considered as suggested by **Israel (1992)** to get the desired minimum sample size at 95 % confidence level and ±8 % precision (*e*).

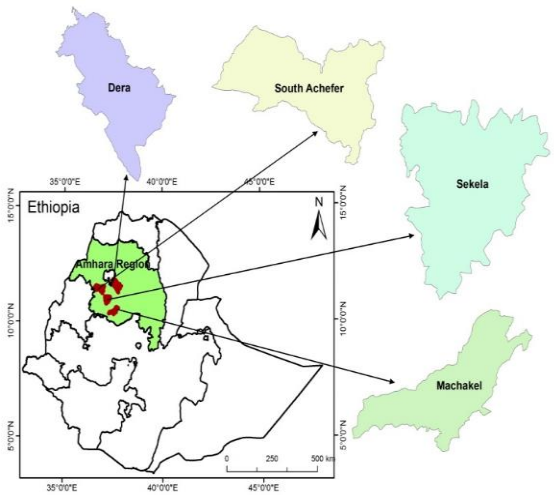

Figure 1. Map of the study areas in the Amhara Region of Ethiopia.

Accordingly, data were collected from both groups using interview schedule at the same time. To give equal chance in selection of the study units from each of the group, probability proportional to size was applied. Consequently, 137 household adopters and 116 non-adopters of crop rotation with lupin were selected.

The survey was conducted in January 2018. Enumerators with local knowledge were recruited and trained in the class as well as in the field. The questionnaire was pre-tested. The pre-test for the survey was conducted in-class training and field practice days. Some of the trainees had some experience with household surveys. Following field practice, a debriefing session was held with the enumerators and modifications to the questionnaires were made based on lessons drawn from the exercise.

Method of Data Analysis

Various qualitative econometric models, such as Linear Probability Model (LPM), Logit, Probit and Tobit Models can be used to establish the relationship between household characteristics and a dichotomous dependent variable. The Logit and Probit models are usually the most commonly used ones. **Gujarati (1995)** states that one can easily use the cumulative distribution function to model regression where the response variable is dichotomous.

Table 1. Distribution of sample farm household heads by district and kebeles

Districts	Total Household Heads	Adopters sample households (N=137)		Non-Adopters Sample households (N=116)		Kebeles	Total Household Heads	Adopters sample households(N=137)		Non-Adopters Sample households (N=116)	
	No.	No.	%	No.	%		No.	No.	%	No.	%
Machakel	23732	46	33.6	31	26.7	Debrekelemu	840	32	27.6	1	0.9
						Amareyewubish	687	0	0	30	25.9
						Amanuel Zuria	864	14	12.1	0	0
Sekela	23914	27	19.7	25	21.6	Abaysengif	969	27	23.3	21	18.1
						Zegezatengeta	595	0	0	4	3.4
South Achefer	26400	23	16.8	17	14.7	Abchekli Zuria	1836	23	19.8	17	14.7
Dera	51998	41	29.9	43	37.1	Huletwegedame	1565	23	19.8	9	7.8
						Tebabari	1416	11	9.5	18	15.5
						Emashenkore	1471	5	4.3	16	13.8
						Gedamgeregera	2996	2	1.7	0	0
Total		137	100	116	100			137	100	116	100

Source: **DADO, 2017**, respective kebeles' records and survey results.

The advantages of these models over the Linear Probability model are that the probabilities are bound between 0 and 1. Moreover, they best fit to the nonlinear relationships between the response and the explanatory variables.

The dependent variable in this case is dichotomous in nature and takes value of zero or one; where zero represents non-adopters crop rotation with lupin and one represents adopters. Crop rotation with lupin is, therefore, a non-continuous dependent variable, which does not satisfy the key assumption in linear regression analysis; that is, a continuous value for dependent variable. Therefore, the study used logistic probability unit (logit) to examine the kind of relationship that exists between adoption decision and the various socio- economic and demographic factors. **Hosmer and Lemeshow (1989)** stated that the logistic distribution has advantage over the others, in the analysis of dichotomous outcome variables, because it is extremely flexible and easily used model from mathematical point of view and results in meaningful interpretations. Following the explanation of **Gujarati (1995)**, the Logit model is specified as in Eq. 2.

$$P_i = E(Y = 1|x_i) = \frac{1}{1+e^{-(\beta_0+\beta_1 x_i)}} \quad (2)$$

Where:
P_i is the probability of being adopter ranging from 0 to 1
Y is the probability of an event to occur or not.
X_i is a vector of relevant household characteristics

For ease of explanation, equation (2) can be expressed as in Eq. 3:

$$P_i = \frac{1}{1+e^{-z_i}} = \frac{e^z}{1+e^z} \quad (3)$$

Where:
$z_i = \beta_0 + \beta_1 x_i$
Zi is a function of *n*-explanatory variables (x_i) and z_i ranges from -∞ to +∞;

x_i is a vector of relevant household characteristics.
If P_i is the probability of being adopter then the probability of non-adopter is given by 1- P_i, which is expressed as in Eq. 4.

$$1 - P_i = \frac{1}{1+e^{z_i}} \quad (4)$$

Therefore, Eq. 4 can be written as Eq. 5:

$$\frac{P_i}{1-P_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i} \quad (5)$$

Where $P_i/(1-P_i)$ is the odds ratio in favour of adopter; the ratio of the probability that the household will be adopter to the probability that it will be non-adopter. Now if one takes the natural log of Eq.5 it is possible to arrive at a log of odds ratio, which is linear not only in x's but also in the parameters (Eq. 6).

$$L_i = \ln(\frac{P_i}{1-P_i}) = z_i = \beta_0 + \beta_i L x_i \quad (6)$$

Where:
L_i is log of odds ratio
If the disturbance term (U_i) is introduced, the logit model becomes as in Eq. 7.

$$z_i = \beta_0 + \beta_i x_i + U_i \quad (7)$$

RESULTS AND DISCUSSION

Descriptive statistics

Households Characteristics

The average age of sample household heads was found to be 46.1 years with standard deviation of 13.15. From the total sample households, about 15.4% were younger or equal to 30 years. The majority of the household heads (73.9%) were found in the age ranges of 31 and 64 years whereas; about 10.7% were older than 64 years. The average family size of the sample households was 5.64

persons, which is larger than the rural national (4.90) and the regional (4.50) averages, respectively (**EDHS, 2016**).

Farmers in the sample households attend on average 5.7 (±2.66) formal schooling years and about 67% of the sample households' heads were able to read and write even though they did not attain formal schooling. Except family size for adoption status, all variables do not have significant difference (p>0.05) between practicing status and across districts (Table 2).

Socio-economic characteristics

The main resource needed by farmers to earn their livelihoods is land. It is the primary and dependable means of living for the rural people of the country as a whole. The average land owned by the farmers in the study area is 1.22 ha with the minimum and maximum value of 0.0 and 4ha respectively. The average landholding size is higher as compare to the national average (1.14 ha) and comparable to the regional average (1.21ha) per household (**CSA, 2014**). It also showed in the study that about 8.3 % of sample farmers were landless and about 50.2 % of the farmers owned land less than 1.00 ha. Moreover, about 35.2 % of households owned land between 1.00 - 2.00 hectares followed by 12.3 % of households holding land size between 2.01 to 3.00 hectares and only about 2.4 % of households having land size between 3.01 to 4.00 hectares. In the survey it is shown that farmers allocated their land for lupin is not more than 5% of the total land cultivated (Table 3).

Table 2. Descriptive statistics of household characteristics between districts, (N=253)

Variables	Total sample	Practicing status		Districts				t-test (Practicing status)	F-test (Districts)
		Adopter	Non-adopter						
	Mean (Std.)	Mean (Std.)	Mean (Std.)	Sekela	Machakel	South Achefer	Dera		
Male headed household (HH) (1=Male)	0.97 (0.16)	0.98 (0.15)	0.97 (0.18)	1.00	0.95	0.97	0.98	0.606	1.071
Age of the HH (Years)	46.1 (13.15)	46.4 (12.08)	45.7 (14.35)	45.7 (11.55)	46.8 (13.08)	44.5 (13.89)	46.4 (13.91)	0.456	0.293
Formal education level of (HH) (Years)	5.7 (2.66)	5.9 (2.40)	5.5 (3.07)	6.1 (2.66)	4.7 (1.57)	6.2 (3.07)	6.4 (2.66)	0.428	1.480
Literate HH (1=Literate)	0.67 (0.47)	0.69 (0.47)	0.66 (0.48)	0.58 (0.50)	0.65 (0.48)	0.75 (0.44)	0.71 (0.45)	0.521	1.366
Family size (No)	5.64 (1.74)	6.01 (1.56)	5.20 (1.84)	5.71 (1.45)	5.67 (1.76)	5.68 (1.69)	5.55 (1.93)	3.819***	0.123

Note: *** represent statistical significance of factors at 1% levels respectively. Values in parentheses (Std.) are standard deviations. HH= Headed Household

Source: Computed from survey data (2018)

Table 3. Proportion of Lupin land to all land cover of sample households across district, 2016/17.

Major crops	Districts name							
	Sekela		Machakel		South Achefer		Dera	
	land cover (ha)	%	land cover (ha)	%	land cover (ha)	%	land cover (ha)	%
Teff	2389	10.99	6365	15.32	5808	14.85	1410	2.23
Wheat	2524	11.61	9727	23.41	1633	4.17	5846	9.23
Barley	4163	19.16	2865	6.89	4512	11.53	3547	5.60
Finger millet	1315	6.05	473	1.14	6377	16.30	12157	19.20
Maize	3684	16.95	7885	18.97	14843	37.94	13880	21.92
Potato	4733	21.78	3269	7.87	737	1.88	5760	9.10
Lupin	544	2.50	427	1.03	2061	5.27	2822	4.46
Other crops	2380	10.95	10547	25.38	3151	8.05	17886	28.25
All crops	21732	100.	41558	100.	39122	100.	63308	100.

Source: Respective districts records (2018)

Table 4. Livestock holding in Total Livestock Unit (TLU) by the sample households across district, 2018.

District name	Sample households No	Mean in TLU	Std. Deviation
Machakel	77	6.71	2.593
Sekela	52	4.37	1.585
South Achefer	40	7.36	3.129
Dera	84	4.60	2.069
Total	253	5.63	2.640

Source: Computed from survey data (2018)

Table 5. Trend of land holding, allocation of land to lupin and yield per household, 2015 – 2018.

	Total land cultivated (ha)				Total land under lupin (ha)				Average lupin yield (t ha^{-1})			
Year	2014/15	2015/16	2016/17	2017/18	2014/15	2015/16	2016/17	2017/18	2014/15	2015/16	2016/17	2017/18
N	73	137	137	137	57	137	137	137	24	125	132	127
Min	0	0.5	0.5	0	0	0	0	0	0.4	0	0.12	0.2
Max	3	3.75	3.75	3.75	0.5	1.25	1	1	1.6	2.8	3.2	3.2
Mean	1.24	1.59	1.62	1.62	0.09	0.25	0.29	0.28	0.95	1.03	1.1	1.11
Std. Dev.	0.939	0.697	0.705	0.738	0.128	0.166	0.161	0.183	0.352	0.558	0.606	0.547

Source: Computed from survey data (2018)

Respondent farmers on average own 5.63 (±2.64) total livestock units (TLU) ranging from 0.0 to 18.25 values and nearly 58% of the respondents have more than 5 TLU whereas, 8% of the respondents possess more than 10 TLU (**FAO, 2004**). Table 4 depicts livestock distribution among the study districts.

Lupin Production

For those farmers who practiced crop rotation with lupin, in all the study areas, about 83.2% produced only the bitter lupin types, the rest farmers (16.8%) in district of South Achefer produced both bitter and sweet lupin. In this district, there are some research interventions on sweet lupin on feeding trials by the Andassa Agricultural Research Center. Yield of lupin was computed based on total grain output per unit of land for those who produce the crop and expressed as tonnes per hectare of land (t/ha). Hence, taking 2017/18 production year, the average yields were 1.11 t ha^{-1} with minimum and maximum value of 0.2 and 3.2 t ha^{-1} respectively (Table 5). There is an upward trend both in yield and land allocation for lupin in the study areas.

Table 6. Reasons for lupin production in the study areas, measured in percentage, N=137.

Reasons for lupin production	Yes	No
Crop rotation to increase soil fertility	92.7	7.3
Favorable land and climatic condition	12.4	87.6
Current market demand for lupin	62.0	38.0
Household consumption	35.0	65.0
Crop diversification	4.4	95.6
Livestock feed	2.2	97.8
High productivity of the crop	6.6	93.4
For fattening of sheep and goats	5.1	94.9

Source: Computed from survey data (2018)

Most farmers (74%) plant lupin after a single plough whereas, the rest plant lupin without ploughing at the onset of the rainy season. Sampled farmers used only improved sweet lupin seed (12.4%) only at South Achefer district. Other district did not use any improved inputs as they thought no need of inputs (44.5%) for lupin production and some also said because of lack of awareness (30%). There is no effective training particularly in lupin production. This could be confirmed from survey result that about 78% of the sample farmers who grow lupin did not get training on lupin production practices. However, Andassa Agricultural Research Center trained farmers in livestock feeding and their extension agents trained farmers how to make green manure using lupin plants in 2017.

Shortage of feed in terms of quality and quantity is one of the leading problem especially during the long dry season because the main feed source is pasture and the farmers lack in experience of feed conservation (**Zewdie, 2015)**. To alleviate this problem different options should be considered. For instance, local bitter white lupin is a very important traditional multipurpose crop and it is grown in mixed crop livestock farming systems of the area (**Yeheyis *et al.*, 2010**). Therefore, sweet lupin can be used as an alternative source of feed for mid and high-altitude areas of Ethiopia. According to **Yeheyis *et al.*, 2011**, feeding trial on Washera sheep (on station) supplementing with 290g/head/day sweet lupin grain have average daily body weight gain of 74 g/day and final body weight of 26.1kg. In the demonstration made by **Molla, *et al.*, 2017** at the Debre Mewi watershed in western Amhara Region, it was found that a 290g/head/day sweet lupin grain supplementation increases the live weight of experimental animals on average from 21.9kg to 29.4kg.

Lupin marketing

Most farmers produce lupin for market and very few for livestock fattening. Farmers sell their lupin grain for whole sellers (54%), retailers (24%), other farmers (2.2%), consumers (2.9%) and combination of all (4.3%). The majority of farmers sell their lupin grain at local market (54.7%) and at home as market point (29.9%) and some in both places (2.2%). Few farmers make lupin snacks and sold to retailers (4.4%) and consumers (1.5%) at local markets. Farmers are motivated to produce lupin as it improves soil fertility and requires minimum labour for production. Based on the observation, there is an increase in demand for lupin snack at homes, groceries and local beer sellers. This brought price increment for lupin and farmers said that they are encouraged to produce more and allocate more land with intensive practice. Farmer to farmer lupin seed exchanges (gifts, bartering) do take place, however, only limited quantities of seed are being sold directly between farmers as they save the necessary seed from previous harvest. In the absence of well-established value chain for seed, it is very difficult to assess the actual demand for quality seed (seed that not be wrinkled, cracked and too small). Therefore, efforts to produce quality seed would need to link producers to either institutional or private buyers.

Lupin Consumption

Based on the survey, consumption of lupin at the farm household level is limited (35% as shown in Table 6 due to a social taboo that says, "Lupin is for the poor and it is unsuitable nutrition". Farmers consume about 13.7% of what they produced (Table 7). However, farmers also recognized that the potential health benefits of lupin, particularly positive effects on blood pressure. Similar studies showed that the consumption of foods supplemented with narrow-leaf lupin flour produced small but statistically significant decreases in blood pressure versus the control foods (**Belski, *et al*., 2011; Lee, *et al*., 2009**).

Estimated Results

All validation tests i.e., multicollinearity (VIF test), model specification (linktest), variable omission (ovtest) and heteroscedasticity (hettest) were made. The results confirmed no problem showed in all tests. In the estimated model the largest VIF test result was 1.53 and the mean VIF was 1.19. Moreover, the value of linktest**,** ovtest and hettest were hatsq > 0.05, prob > F= 0.1836 and prob > chi^2= 0.7257, respectively. From the econometric outputs, the following variables were statistically significant in affecting the decision of farmers to practice crop rotation with lupin.

Family size (Number of persons in the household): Though lupin production is not labour-intensive currently, as farmers do not spend much time on their lupin fields, the result showed that for a one-unit increase in family size, we expect a 0.332 increase in the log -odds of crop rotation with lupin, holding all other independent variables constant. Therefore, farmers' decision on the adoption of crop rotation with lupin dependent on the availability of labour force in the household.

Land holding Size (ha): This refers to the total farmland that a farmer owns measured in hectares. Farmers operating on a larger area of land generally allocate part of it for lupin as a break crop for the subsequent production year with major crops like teff, wheat maize or others. The result showed that for a one--unit increase in farmland holdings, it is expected to have a 0.794 increase in the log odds of crop rotation with lupin, holding all other independent variables constant. It affects farmers' decision of crop rotation with lupin positively and significantly at 1% level.

Table 7. Production, consumption and marketing per household of lupin, 2017.

Descriptions	N	Minimum	Maximum	Mean	Std. Deviation
Total Production, kg	130	0	1200	322.5	200.13
Home consumption, kg	129	0	400	44.1	54.14
Used for seed, kg	127	0	100	12.2	24.93
Bitter lupin sold, kg	129	0	900	257.2	182.55
Sweet lupin sold, kg	129	0	300	6.4	36.55

Source: Computed from survey data (2018)

Table 8. Maximum likelihood estimates of the logit model

Variables	Coefficients	Robust Std. Err.	Odds Ratio	Robust Std. Err.	Marginal Effect (dy/dx)
Sex (Dummy)	0.704	0.841	2.021	1.700	0.175
Age (Year)	-0.025	0.015	0.976	0.015	-0.006
Education (Dummy)	0.257	0.354	1.293	0.458	0.064
Family Size (Number)	0.332***	0.098	1.394***	0.136	0.083
Total landholding (ha)	0.794***	0.259	2.212***	0.573	0.197
Livestock holding (TLU)	0.135*	0.067	1.144*	0.077	0.034
Market Distance (km)	0.004	0.005	1.004	0.005	0.001
Extension contact (Dummy)	0.451***	0.161	1.570***	0.253	0.112
Constant	-4.124***	1.165	0.0162***	0.019	-
Log likelihood = -358.333					
LR chi2(8) = 52.94	Prob > chi2 = 0.000				
Pseudo R2 = 0.187	No. Observations = 253				

Source: model results

Livestock holding (TLU): The result showed that for a one-unit increase in livestock holdings, it is expected to have a 0.135 increase in the log odds of crop rotation with lupin, holding all other independent variables constant. It affects farmers' decision of crop rotation with lupin positively and significantly at 10% level.

Extension contacts (dummy): This is a dummy variable, which measures whether a farmer has contacts with extension workers or not in a year. It has positive influence on farmers' decision of crop rotation with lupin (significant at 1% level). The higher the linkage between farmers and extension workers, the more the information flows and the technological (knowledge) transfer from the latter to the former.

CONCLUSIONS AND RECOMMENDATIONS

According to the results of this study the probability of practicing crop rotation with lupin appears to be significantly and positively influenced by family size, total farmland holdings, livestock holdings and the level of contact with agricultural extension workers.

As the market price is increasing for lupin, this will made farmers encourage in producing and allocating more land with intensive practice. This intensive practice needs more labour. Therefore, this will be a good opportunity for rural labour employment. Hence, local government should design their development strategies towards improving the marketing system of lupin to benefit all actors.

Lupin production is done traditionally with low inputs. However, the current market demand for the crop might encourage farmers to produce lupin with more intensive farming approaches. This requires more land allocation and use of improved technologies, such as improved land management, use of improved seed, provision of continuous training and other appropriate supports.

Extension contact is a very important variable that positively influenced the decision to practice crop rotation with lupin. Since extension services are the main instrument used in the promotion of best farming practices, timely and adequate extension services should be provided. Therefore, it is important to design appropriate capacity building program for development agents (DAs), like on job training. Moreover, recruit additional development agents is necessary to reduce burden of DAs.

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REGULAR ARTICLE

FARMERS' CHOICE OF ADAPTATION STRATEGIES TO CLIMATE CHANGE AND VARIABILITY IN ARID REGION OF GHANA

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ABSTRACT

This study used multinomial logit regression to determine the factors that influence farmers' choice of adaptation strategies to climate change and variability of farmers in Savelugu-Nanton district, Northern region of Ghana. A simple random sampling was used to select 180 farmers. The data was analysed using a Multinomial logit regression model. From the results, the level of climate change and variability awareness was high and the adaptation strategies identified were mixed cropping, change crop varieties, changing planting time/date, soil conservation techniques, increased irrigation, increased female livestock herd, and seasonal migration. Farmers confirmed empirically observations that climate change would lead to a reduction in crop production. Also, gender, age, education, household size, farming experience, access to extension, access to credit, access to mobile phone and perceived decreased rainfall influenced farmers' choices of a particular adaptation strategy. The findings support and justified calls for education of farmers on climate change and variability.

Keywords: Adaptation; Climate change and variability; Multinomial Logit Regression model; Perception
JEL: C31, C35, N50, O13, Q12

INTRODUCTION

In recent decades, climate change and variability (CCV) is one of the most topical issues. This is particularly due to the effects it has on other developmental challenges such as food security and poverty as well as its effect on a stable environment for future generations. Its effect on sustainable development is negative and manifested in all sectors of the economy. Generally, the conclusions from climate literature suggests a 'changing climate'. However, the trends, impacts and response thereof are not universally distributed. One of the most vulnerable locations is the Africa continent **(Arslan *et al.*, 2015;Nyasimi *et al.*, 2014)**, where Ghana is located. This is largely due to the fragility of African economies and their low adaptive capacities.

Climate model projections show that rainfall patterns would become more erratic and unpredictable than currently observed **(Serdeczny *et al.*, 2016; Laube *et al.*, 2012)** while temperatures would rise. Over the 20th century, precipitation decreased by 3% in the subtropical areas **(Uddin *et al.*, 2014)**. Expectedly, the effects on all sector, especially, the agriculture sector gained documentation in recent times. Ghana's climatic conditions have changed in the past four decades and this phenomenon is expected to continue in the future **(Stanturf *et al.*, 2011)**. Already, the country is experiencing increasing temperatures and erratic rainfall patterns. Unfortunately, among the various sectors, agriculture sector, especially in the African region, is most vulnerable. This is due to the high dependence of the sector on natural resources **(Nhemachena and Hassan, 2007)** and the low adoption of modern technologies **(Jones and Thornton, 2003; Kurukulasuriya and Rosenthal, 2003)**. However, Africa's vulnerability to climate change is complex (Nyasimi et al., 2014). Estimates show that crop yields in the continent is likely to see as high as 50% reduction by 2050 due to climate change **(Jones and Thornton, 2003)**. The undernourishment in sub-Saharan Africa would increase by 25-90% by 2050 if warming increase between 1.2-1.7^{o}C **(Lloyd *et al.*, 2011)**.

Responding to CCV requires mitigation and/or adaptation. While the former is generally long-term strategy, the latter are short-term and localized measures to offset the impacts of CCV. As simply put, societies must adapt to ensure survival of lives **(Arku, 2013)**. Adaptations, which is the focus of this study is defined as the interventions carried out to improve society's capacity to adjust to CCV, reduce the negative effect or take advantage of the opportunities offered by a changing climate. Adaptation to climate change is of two types; autonomous and planned adaptation. Autonomous adaptation is a short-run micro-analysis of farmer decision in response to seasonal climatic variations, economic and other factors whiles planned adaptation is the long-run macro-analysis at national or regional levels focusing on the long-term climatic changes, market and other factors

(Bradshaw *et al.*, 2004). The study however focused on autonomous adaptation.

Farmers under various conditions adopts various adaptation strategies, primarily, to increase or at least, maintain crop yields. CCV cannot be sufficiently addressed if effective adaptation strategies are not adopted **(Nyasimi *et al.*, 2014)**. With further pressure on agricultural livelihoods, farmers further adopt various coping and adaptation strategies **(Laube *et al.*, 2012)** in order to maintain their livelihoods. For instance, unlike previous decades where irrigation facilities are solely provided by the government, farmers have recently engaged in farmer-driven irrigation farming to provide food for their families. As has been the case globally, farmers in Ghana have engaged in a number of innovative strategies due to diverse economic and environmental challenges. This notwithstanding, **(Phillipo *et al.*, 2015)** noted that knowledge on adaptation to CCV in sub-Saharan Africa is dotted due to the absence of comprehensive adaptation framework. This is not surprising as several adaptation strategies including crop diversification, mixed cropping, mixed crop-livestock farming systems, irrigation, using drought resistant varieties, high-yield water sensitive crops, migration, changing planting and harvesting dates, and modifying the length of the growing period were adopted and reported in the literature **(Nzeadibe *et al.*, 2011; Enete *et al.*, 2011; Codjoe and Owusu, 2011; Hassan and Nhemachena, 2008; Quaye, 2008)**.

Scholarly review of farmers' adaptation to CCV has gained prominence. Therefore, a stock of current literature is important to give focus of this present study. From the literature, knowledge on climate change have a major implication on adaptation. Farming households that are able to predict the trend of the climatic conditions correctly may be able to select responsive adaptation strategies. Similarly, the choice of adaptation strategy depends on the soil properties, location and climatic conditions of an area **(Uddin *et al.*, 2014)**. Besides technological revolution, local practice (the various activities implemented by farmers) is important in the success of CCV adaptation. Empirical estimations revealed a number of factors that influence CCV adaptation or adaptation intensity **(Mabe *et al.*, 2014; Uddin *et al.*, 2014)**.

The role of agriculture in Ghana's economy is inevitable. It provides food and income for majority of the population **(Al-hassan, 2007)**, employs most of the populace and also contributes greatly to the foreign exchange earnings in the country. However, farming in the country is dominated by small-scale farmers with very low productivity that is attributable to outmoded farming techniques; soil degradation caused by overgrazing and deforestation; poor agricultural and financial services and frequent floods and droughts. The high reliance of Ghana's economy on agriculture called for sustainable adaptation to CCV. This must involve the adoption of most effective, efficient and localized adaptation strategies. Due to its geographical location and low adaptive capacities, the northern parts of Ghana is more vulnerable to CCV. Agriculture is also a pronounced economic activity in the north than in the south. These conditions mean that deliberate efforts, at least through research must be conducted in these areas to provide periodic evidence-based recommendations to policy makers. Therefore, although there is vast literature on CCV adaptation, the case of farming household in the northern parts of Ghana requires a further review. In addition, conflicting results exist particularly when it comes to the determining factors of adaptation. Some of the factors identified by past researchers are famers' socio-economic characteristics, farm characteristics and farm management practices **(Nzeadibe *et al.*, 2011; Hassan and Nhemachena, 2008)**. It is therefore impossible to apply recommendations from these studies to farming households in the study area without a restriction. This study addresses these limitations by identifying the CCV adaptation strategies in the Municipality and the factors responsible for their adoption. The aim is to provide policy recommendations that would enhance farmers' adaptation to CCV and ensure that the impacts from CCV are reduced.

DATA AND METHODS

Theoretical framework

The theory behind this study is the utility maximization theory. The theory suggests that economic agents (farmers) are rational and if faced with the decision to choose among two or more CCV adaptation strategies, they will prefer the option that gives the highest utility or net benefit. In this study, farmers are assumed to maximize their utility or net benefits if they adopt a particular strategy. Hence, the probability that an adaptation strategy is chosen depends on the expected utility from that adaptation strategy. Assume that farmer *i's* utility from adopting adaptation strategy *j* is given as in Eq. 1.

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (1)$$

Where: U_{ij} is farmer *i's* utility of choosing alternative *j*, V_{ij} is the deterministic component of utility and ε_{ij} is a stochastic element that represents unobservable influences on the farmer's choice. Using utility functions for two alternatives from (Eq. 1), the probabilities of a farmer choosing, say alternative *j* or *k* are in Eq. 2.

$$P_{ij} = P(\varepsilon_{ij} - \varepsilon_{ik} < V_{ik} - V_{ij})$$
$$P_{ik} = P(\varepsilon_{ik} - \varepsilon_{ij} < V_{ij} - V_{ik}) \quad (2)$$

The probability that any particular respondent prefers option *j* in the choice set to any alternative option *k*, can be expressed as the probability that the utility associated with option *j* exceeds that associated with the other options (Eq. 3).

$$P_{ij} = P\{V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik} \; \nabla k \in C\} \quad (3)$$

Where: *C* is the set of all possible alternatives. In order to derive an explicit expression for these probabilities, an assumption is made about the distribution of the error terms. Assuming that error terms are independently

Gumbel distributed the probability of choosing alternative j can be expressed as Eq. 4.

$$P_{ij} = \frac{e^{X_{ij}\beta_j}}{\sum_{K=1}^{J} e^{X_{ik}\beta_k}} \quad (4)$$

Equation 4 is known as the Multinomial logit model (MNL) which gives the probability that farmer i will choose adaptation strategy j among C alternatives **(McFadden, 1973)**, β_j are the vector coefficients yet to be estimated and X_{ij} denotes vector of explanatory variables which represents farmers' socio-economic characteristics, farm characteristics and perception of CCV. An important implication of this specification that follows from the independence of the error terms across the different options contained in the choice set is the property of the independence of irrelevant alternatives. This property requires that the probability of an option being chosen should be unaffected by the inclusion or omission of other alternatives **(Hausman and McFaden, 1984)**.

Taking the differential of equation (4) with respect to the explanatory variables gives the marginal effects of the explanatory variables, which measures the expected change in probability of a particular option chosen with respect to a unit change in an explanatory variable from the mean **(Greene, 2012)**. The marginal effects equation is presented as:

$$\frac{dP_j}{dP_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{J-1} P_j\, \beta_{jk}\right) \quad (5)$$

Empirical Model

The MNL is used to analyse the determinants of farmers' decision to adopt a particular adaptation strategy in Ghana. This model is commonly used in adoption decision studies involving multiple choices **(Hassan and Nhemachena, 2008)**. The MNL has advantages over binary probit or logit because it allows the analysis of decisions across more than two categories, correct for self-selection and interactions between different categories and also simple to compute **(Tse, 1987)**. The estimated empirical model is expressed as:

$$Y_i = \beta_0 + \beta_1 age + \beta_2 edu + \beta_3 gender + \beta_4 farmsize + \beta_5 hhsize + \beta_6 mar + \beta_7 farmexp + \beta_8 amobile + \beta_9 aext + \beta_{10} acredit + \beta_{11} Prain + \beta_{12} Ptemp + \varepsilon_i \quad (6)$$

The dependent variable in the empirical model is the choice of an adaptation option from the set of adaptation strategies. These are soil and water conservation, changing crop varieties, increased irrigation, changing planting date/time as well as engaging in mixed cropping. The choice of the explanatory variables (Table 1) is based on data accessibility and literature.

The Study Area

The study was carried out in the Savelugu-Nanton district which has Savelugu as its capital town. With a population of 139,283 and a land area of 1790.7 square km, the population density is about 61 person per sq.km. There are 149 communities in the district of which 143 are rural, and approximately 80% of the populace resides in rural communities and 20% in the few urban towns. Savelugu-Nanton district is predominantly agrarian with about 97% of the district's economically active population (18-54years) involved in farming of staple food crops. The major crops include maize, rice, yam, groundnut, cowpea and soybean. Agricultural practices are mainly dependent on rainfall which is erratic resulting in seasonal unemployment.

Table 1: Description, Measurement and A priori Expectations of Explanatory variables.

Variables	Description	Measurement	A priori
Gender	Gender of farmer	1 if male, 0 otherwise	-/+
Age	Age	Years	-
Mar	Marital status	1 if married, 0 otherwise	-/+
Edu	Educational level	1 if formal education, 0 otherwise	+
Farmexp	Farming experience	Number of years of farming	+
Farm size	Farm size	Acres	+
Hhsize	Household size	Number of household members	-/+
Acredit	Access to credit	1 if access, 0 otherwise	+
Aext	Access to extension	1 if access, 0 otherwise	+
Amobile	Mobile phone access (owning a phone)	1 if access, 0 otherwise	+
Ptemp	Perceived increased temperature	1 if increased, 0 otherwise	+
Prain	Perceived decreased in rainfall	1 if decreased, 0 otherwise	+

Sampling, Data collection and Analysis

Savelugu Nanton district was purposively selected because most of the communities' major sources of livelihoods are highly climate dependent which makes them highly vulnerable to the negative impacts of CCV. Already, there are signs of CCV in the Municipality. Two communities Libga and Zoggu were randomly selected and with the help of the District extension officers, lists of small holder farmers in the communities were obtained. From the list 180 small holder farmers were randomly sampled and data was obtained through semi- structured questionnaires. The information gathered include farmers' socio-economic and demographic features, farm characteristics, farmers' perceptions of changes in temperature and rainfall, and self-reported CCV adaptation strategies. Two focus group discussions were conducted to collect qualitative information on perceptions and experiences of 10 farmers (six males and four female farmers) from each community. Qualitative data were recorded, transcribed and analysed using content analysis to bring out various themes. The quantitative data were analysed using Stata 14.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

The survey (as shown in Table 2) in the study area covered 65% male farmer respondents and 35% female farmers. Majority of the respondents (65%) are married while 35% are single. The mean age of the respondents is 33. 8 years with youngest and oldest farmer having ages 17 years and 67 years, respectively. The educational level of the respondents is low as only 37.2% have some level of formal education. Approximately, there are 7 people in each sampled household. The mean farming experience is 19.42years, with the least and maximum being 2 years and 50 years respectively. The high experience in farming by the farmers means that the farmers can be able to notice any variation in the environmental conditions and act timely. Averagely, a farmer cultivated 6.52 acres of land. More than half (54.9 %) of the farmers received Agricultural extension services through contact. Also 61.7% and 79.7 % of the farmers have access to credit facilities and mobile phone, respectively.

Table 2: Socio-economic characteristics of the respondents

Variables	Frequency	Percentage
Gender		
Male	117	65
Female	63	35
Total	180	100
Educational level		
Formal education	67	37.2
No formal education	113	62.8
Total	180	100
Marital status		
Married	117	65
Not married	63	35
Total	180	100

Farmers' awareness of CCV in the area

CCV awareness and knowledge is key in facilitating adoption of strategies that could be efficient under than socioeconomic conditions. It also influences the decision and rate at which smallholder farmers adopt modern and improved technologies available to minimize the harmful effect of CCV. Therefore, understanding farmers' knowledge on CCV have become the first step in adaptation studies. The implication drawn from previous studies is that adaptation to CCV is high if farmer's knowledge/awareness on changes of temperature and rainfall is high. To get information on their perceptions to CCV, farmers were asked two sets of questions. Firstly, farmers were asked if they knew about CCV and secondly, if they have observed any change in rainfall intensity or temperature over the past ten years. The result is presented in Table 3.

The result shows that most of the farmers interviewed (83.9 %) were aware or knew of CCV. Of this group of farmers, as high as 82.8% of them had observed increasing temperature over the past 10 years, against 7.2% observed decreasing temperature and 10% had not observed any change in temperature over the past 10 years. With respect to changes in rainfall, majority (85.7%) had observed decreasing rainfall whilst 14.3% reported that the intensity of the rains is increasing over the past 10 years. These individual farmer's perceptions were confirmed through focus group discussion. Below are some extracts from the focus group discussion:

"For the past 10 years access to water for irrigation is limited because the quantities of rain have reduced, most of our dugouts have dried up and are not able to provide us with water until the rainy season begins".

"Now we [can] sleep outside in the month of June-July because our room is warm, but that was not the case in the past. In the past around this period the weather was too cold that, we have to sleep in our rooms".

This shows that the people are adjusting the living conditions in line with their observed changes in the climatic conditions. The high perception of farmers on CCV have been observed in earlier empirical studies **(Limantol *et al*., 2016; Tadesse, 2009; Uddin *et al*., 2014; Mertz *et al*., 2009)**.

Perceived Effects of changes in temperature and rainfall

In addition to understanding farmers' perceptions on CCV, perceptions on the effects of these observed changes is vital. In Table 4, the result of farmers' perception on these effects is provided. Firstly, changes in temperature and rainfall has led to poor crop production (33.3%). This confirms reports that CCV would have a negative effect on food production, for that matter, food security **(Barimah *et al*., 2018)**. Farmer's dependence on rain-fed agriculture and natural resources as a sole source of livelihood is threatened by the variations in climatic conditions that directly affects agricultural productivity.

The second effect reported was water scarcity due to reduction in the quantity of rainfall (21.7%). On their part, not only is low rainfalls affecting crop production but also, water availability for domestic purposes during some months in the harmattan season. This supports claims that climate change and population growth are mainly responsible for water scarcity and limiting irrigation potentials **(Turner *et al*., 2011)**. A participant in the focus group discussion noted:

"Most of the dugouts have dried up, making it difficult for livestock to get water to drink and farmers to get water for irrigation."

About 18.6% reported increase in soil erosion/declining soil fertility. Soil infertility occurs when the mining of soil nutrients exceeds their replenishment, resulting in a negative balance of nutrients. With CCV, high temperature can contribute to low soil productivity as it tends to reduce water in the soil. Consequently, this affects nutrient mineralization and their availability to crops **(Rowell, 1995)**.

The tendency of prevalence of resilient pests and diseases was reported by 12.4% of the farmers. Thus, with increasing temperature and decreasing rainfalls, not would the pests and diseases increase, but they would be more resistant to existing control measures. Climate change has the ability to change the incidence of existing vector-borne

diseases in humans and crops **(FAO, 2007)** and also affect the populations of insects and other vectors **(Lema and Majule, 2009)**. The effects on pests and diseases is also report during focus group discussion:
"The livestock have been getting strange diseases and most usually die from these diseases".

Other effects include poor livestock production (8.30%) and increased suffering and poverty (5.7%). Consistently, **(Gandure and Alam, 2006)** reported that CCV has the tendency of impoverishing rural farmers. Also noted by a participant in focus group discussion is:
"Due to erratic rainfall and high temperature our crop yield is low, reducing our income and this has increased our sufferings".

Farmers' adaptive strategy to climate change and variability (CCV)

One of the aims of the study is to explore the various adaptation strategies used by farmers in response to CCV. The farmers have responded to changes in rainfall and temperature by adopting mixed cropping, changing planting date, increased irrigation, seasonal migrating to urban areas, changing crop variety, increasing female livestock and soil conservation techniques. They were however some who did nothing or did not adapt to the changing climatic conditions.

Mixed cropping involves the growing of two or more crops in proximity in the same field **(Lema and Majule, 2009)**. This have the potential to curtail complete crop failure as different crops are affected differently by climate. For a staple crop, such as maize, instead of planting local varieties, farmers have opted to combine both local and improved varieties while some have completely shifted from local varieties to early maturing improved varieties. Since the onset of the rains have changed, farmers also do not plant their crops in the same periods as decades back. As a risk sharing measure, other farmers reported keeping female dominated herds to sustain and supplement their income. Relatedly, participants in focus group discussion noted:

"When crop fails due to unreliability of rain, and an alternative means of generating income is not possible, I sell my livestock to feed the family and buy farm inputs for the next season".

"To increase or maintain the number of livestock, I always sell the male animal and keep the females for reproduction. I do this to sustain my income in case the rain fails"

Seasonal migration, especially, by the youths is a major adaptation strategy to CCV. People either locate to farming areas where the soils are relatively fertile and the rains are regular for farming activities or move to the urban and peri-urban areas for non-agricultural jobs.

Mostly, young people from the north migrate to southern Ghana during the dry season after harvesting and return in the rainy season to resume with their farming activities. Others may not return for farming but send remittances to reduce economic difficulties of their families.
Quoted from focus group discussion is:

"My children have to travel to Kumasi for Kayaye [head porting] during the dry season and return during the planting and harvest period to help with planting and harvesting"

"…. I have to go to Kumasi to help in my senior brother['s] business and earn some income, which I use to feed my family".

However, farmers who failed to adapt also have their reasons. This includes insufficient credit facility, high cost of labour, high cost of irrigation and lack of ready market; all related to financial constraints. In their words:

"I do not have enough fund to buy pump for irrigation, it is expensive"; "it is expensive to pay labourers to worked on my farm"; and "farm inputs like fertilizer, improved crop varieties etc. are expensive nowadays"

"because we are farmers, banks don't want to give us loan, its difficult accessing credit as a farmer"

The fact that financial matters dominate is an indication that adapting to climate change is expensive and the lack of sufficient financial resources will prevent farmers from purchasing the necessary inputs and equipment needed to adapt. Consistently, **Enete *et al.* (2011)** reported inadequate funding as a major challenge to adaptation to CCV.

Table 3: Farmers awareness and Perceived Changes in temperature and rainfall

Perception on CCV	Frequency	Percentage
Perceived	151	83.9
Not perceived	29	16.1
Total	180	100
Perceived changes in temperature		
Increased temperature	125	82.8
Decreased temperature	11	7.2
No changes in temperature	15	10
Total	151	100
Perceived changes in Rainfall		
Increased rainfall	22	14.3
Decreased rainfall	129	85.7
No changes in rainfall	0	0
Total	151	100

Adoption of climate adaptation strategies by farmers

Table 4 shows the percentage distribution of the adoption of climate adaptation strategies by the farmers. At the focus group discussion, farmers listed eight adaptation strategies that they have adopted to reduce the negative effect of CCV. Out of these, six (mixed cropping, change of crop variety, changing planting time/date, adoption of soil conservation techniques, increased irrigation and no adaptation) farm management practices were identified as most important by the farmers. These are also outlined as prominent adaptation strategies in the literature **(Codjoe and Owusu, 2011; Phillipo *et al.*, 2015; Hassan and Nhemachena, 2008; Quaye, 2008)**. From Table 5, about 11.67% adapt none of the six strategies, 11.12% used soil conservation techniques, 15 % changed crop varieties, 16.11% engaged in irrigated farming, 20 % change planting date while 26.11% mixed cropping.

Determinants of farmers' choice of adaptation strategy to climate change and variability

The results of the estimates of the marginal effects along with the levels of statistical significance from the MNL are presented in Table 6. The dependent variable in the empirical model for this study is the choice of adaptation option from the set of adaptation strategies (Table 5) and the reference group assumed is the zero adaptors. From the result, a number of factors had significant effect on the various climate adaptation strategies and this is discussed in the subsequent sections.

Table 4: Perceived Effects of Changes in temperature and rainfall on farmers*

Perceived effects of changes in temperature and rainfall	Percentage
Poor crop production	33.3
Water scarcity	21.7
Soil erosion/declining soil fertility	18.6
Increased pest and disease	12.4
Poor livestock production	8.3
Increased suffering and poverty	5.7
Total	100

Note: Perceived effect reported by 151 respondents who had perceived changes in temperature and rainfall.

Table 5: Adaptation strategies used in the MNL model

Adaptation Strategies	Percentage
No adaptation	11.67
Soil Conservation techniques	11.12
Changing crop varieties	15.00
Increased Irrigation	16.11
Changing planting date/ time	20
Mixed cropping	26.10
Total	100

Table 6: The Marginal effect of MNL Estimation

Explanatory Variables	Soil conservation	Changing crop varieties	Increased Irrigation	Changing planting date/time	Mixed cropping
Age	-0.0037 *	-0.044*	0.0538	0.01548	-0.0549
	(0.0940)	(0.0944)	(0.169)	(0.2169)	(0.318)
Gender	-0.03494	-0.1465	0.0065	-0.04106**	-0.05408
	(0.206)	(0.2077)	(0.2270)	(0.0356)	(0.384)
Education	-0.006475	0. 01287**	0.02494	0.1382	0.00429
	(0.166)	(0.026)	(0.685)	(0.872)	(0.687)
Marital status	-0.02035	0.05422	0.0354	0.5117	0.00943
	(0.190)	(0.484)	(0.584)	(0.691)	(0.114)
Fexperience	-0.0215	-0.0452	-0.00337	0.0071*	0.0056
	(0.679)	(0.476)	(0.717)	(0.090)	(0.167)
Fsize	0.03469	0.01451	0.005436	0.0014	-0.00277
	(0.587)	(0.385)	(0.857)	(0.1165)	(0.758)
Hhsize	-0.0039	-0.00754	-0.03459*	-0.00271	0.0067
	(0.935)	(0.315)	(0.064)	(0.733)	(0.213)
Access to ext	-0.01624	0.0999**	0.01017	0.0052	0.0083
	(0.722)	(0.021)	(0.786)	(0.293)	(0.034)**
Access credit	0.0068*	0.0011	0.0088	0.0036	0.0055
	(0.101)	(0.528)	(0.667)	(0.533)	(0.332)
Access to mobile phone	0.0429**	0.0025	0.0631	0.0723	0.0087
	(0.054)	(0.277)	(0.111)	(0.0213)**	(0.442)
Prain	0.0229	0.0335	0.01010	0.0669	0.0885
	(0.1254)	(0.2234)	(0.2121)	(0.3423)	(0.080)**
Ptemp	0.00213	0.04332	0.09921	0.05432	0.06098
	(0.1356)	(0.5432)	(0.3421)	(0.1235)	(0.2327)
Constant	-0.02994	-0.01531**	-0.0752	-0.0496***	-0.0884
	(0.783)	(0.045)	(0.116)	(0.002)	(0.345)
LR Chi 2	68.9874**				
Pseudo R2	0.2108				
Log likelihood	-287.1667				

Notes: Base category: No adaptation. *,** and *** indicates 10%, 5% and 1% levels of statistical significance respectively. p-values are in the parenthesis

Factors influencing the adoption of soil conservation Techniques

As shown in Table 6, the factors which significantly affect the probability of farmers using soil conservation techniques as an adaptive strategy are age (significant at 10%), access to credit (significant at 10%) and access to mobile phone (significant at 5%). While age had a negative effect on the likelihood that the farmer would adapt soil conservative techniques, access to credit and access to mobile phone had a positive effect. Congruent to a priori expectation, farmers with access to credit were more likely to adapt to CCV using soil conservation techniques since they have adequate funds used to acquire the needed materials or farm inputs needed for adaptation. Recall that financial constraint was a major reason for zero adaptation by some farmers. This finding is consistent with **Gbetibouo (2009)** but contradicts **Salau *et al.* (2012).** The result shows the essence of supporting farmers with credit to promote the use of adaptation options, so as to reduce the negative impact of climate change and variability.

The result of age suggests that the younger farmers have a higher probability of adapting soil conservative techniques. Naturally, the younger farmers are more energetic and quick to adopt new technologies than the elderly. Older farmers are more risk-averse and also get used to a particular way of doing things and thus might have a lesser likelihood of adopting soil conservation technique in adapting to CCV. **Dolisca *et al.* (2006)** also observed that a negative effect of age on CCV adaptation but contrary to **Ndambiri *et al.* (2013)**.

Consistent to apriori and **Mabe *et al.* (2014)** farmers with access to mobile phone have a high probability of adapting soil conservation techniques in response to CCV. The reason may be that farmers with access to phone easily get good farm management practices information on their phone from farmer-based organizations or can communicate with other long distant farmers.

Changing crop varieties

The factors which influence farmer's decision to change crop varieties in response to CCV are age, education, and access to extension services. Again, the marginal effect of age is negative and significant at 10%. This suggests that younger farmers are more likely to change crop varieties as an adaptive strategy than older farmers. The implications drawn under soil conservation are applicable since the younger farmers are generally risk bearers and would want to try any new crop variety. **Uddin *et al.* (2014)** also estimated a negative effect of age on CCV adaptation.

Education has positive significant relationship with farmers' changing of crop varieties as an adaptation strategy. Formal education equips individuals with the ability and understanding of new varieties and this have effect on the adaptation decision making **(Gbetibouo, 2009)**. A higher level of education of a farmer is likely to be associated with knowledge and information on CCV, improved technologies, and higher productivity and accordingly appropriate adaptive method would be chosen.

The positive relationship between access to extension services and the farmer's decision to adopt improved crop varieties is an indication to enhance extension service delivery and its quality to the farmers. Extension officers provide information to farmers on production practices including input usage. In recent times, extension officers direct farmers to appropriate stations to obtain the required inputs such as seed varieties. This was estimated by **Tadesse *et al*. (2009)** and also argued that farmers who have access to extension services are in the best position to receive information about adaptation methods to climate change.

Irrigation

The result in Table 6 indicates that household size (significant at 5%) is the only variable that influences farmer's decision to adopt irrigation as adaptation strategy. Contrary to a priori expectation but consistent with **Ndambiri *et al.* (2013)**, household size had negative coefficient like. As explained by **Ndambiri *et al.* (2013)**, the need to earn more family income may force some households to divert part of their labour force to off-farm activities. On the flipside, **Croppenstedt *et al.* (2003)** argues that large households are more likely to adopt agricultural technology and use it more intensively since they have more labour.

Changing Planting date/time

Farmer experience, gender and access to mobile phone significantly affect farmer's decision to change planting time as adaptation strategy to CCV (Table 6). In our present study the positive relationship between farming experience (significant at 10%) and decision to adapt to climate change is confirmed by **Hassan and Nhemachena (2008)** who explained that experienced farmers have better knowledge and information on changes in climatic conditions and crop management practices.

The estimate negative sign of gender means that female farmers have a higher probability of changing their planting dates than the male farmers. Generally, women are reported as more vulnerable to CCV. Therefore, it is not surprising that they would change their planting dates to respond timely to CCV. Unlike other adaptation strategies that require physical strength which naturally favour the male farmers, changing of planting dates have no relationship with physical strength. This could explain the high probability of its adoption by the female farmers.

As expected, farmers' access to mobile phone positively influences their decision to change planting date as an adaptation strategy. Implying that farmers with access to mobile phone are more likely to change planting time than those without access. With the increasing usage of internet and the influx of social media such as Facebook and WhatsApp, the role of mobile phone access, especially, smart phones cannot be underestimated. People including farmers gets to know of some climate issues through these media. Friends are able to communicate to their farmers on news of the onset of the rains (as may be reported by meteorological departments) in order to act accordingly. Hence the positive effect on changing planting dates, as estimated by **Mabe *et al.* (2014)**.

Mixed Cropping

From Table 6, farmer's decision to adopt mixed cropping as an adaptation strategy is influence by access to extension and perception on reduced rainfall. Like changing planting dates, farmers engage in mixed cropping with better information from extension officers. The positive relationship between access to extension services and the farmer's decision to adopt mixed cropping. Perception on rainfall positively influence mixed cropping decisions in order to reduce impacts of CCV. The finding of perceived reduced rainfall is expected, because farmers who perceived a decrease in rainfall may want to avoid complete crop failure by planting different crops which requires different water levels. This was also found in **Lema and Majule (2009)**.

CONCLUSIONS AND POLICY IMPLICATIONS

The main objective of this study has been to assess the views and knowledge of smallholder farmers on CCV, its impacts, and the various adaptation strategies and their determinants. Generally, the level of climate change awareness was high and most of them noted the effect of CCV on agriculture as poor crop production, increased water scarcity and increased pests and diseases. Farmers in the study area use different adaptation strategies to mitigate the negative effect of CCV and these includes mixed cropping, change crop variety, change planting time/date, adoption of soil conservation techniques, increased irrigation, migration to urban area, and increased female livestock herd. MNL was used to examine factors influencing farmers CCV adaptation choices. Conclusively, although there are exceptions, the factors that influenced one adaptation strategy may not necessarily influenced another. Therefore, the promotion of composite strategies needs to be carefully made, considering the socioeconomic characteristics of the farmers.

Although, most of the smallholder farmers were aware about CCV, there is still the need for farmers' education, awareness creation, provision of accessible and affordable credit and improved and modern technology to farmers as effective tools for climate change and variability adaption in the study area. The provision of extension services needs to be enhanced in order to enhance farmers' adaptation.

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REGULAR ARTICLE

IMPACT OF AGRICULTURAL PROTECTION ON AGRICULTURAL GROWTH IN NIGERIA: POLITICAL ECONOMY PERSPECTIVE (1980-2016)

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ABSTRACT

This study examined the impact of agricultural protection and other macroeconomic variables on agricultural growth in Nigeria from 1980 to 2016. The specific objectives were to (i) estimate the level of agricultural protection in Nigeria; (ii) determine the effects of agricultural protection on agricultural growth, and (iii) analyse the causal relationship between agricultural protection and agricultural growth in Nigeria. The data were obtained from annual time series dataset from Central Bank of Nigeria (CBN), World Bank, and Food and Agriculture Organisation (FAO) and were tested using unit root and cointegration tests. Descriptive statistics, Nominal Protection Coefficient (NPC) model, multiple regression and Granger causality were analytical test used, while the hypotheses were tested with F-test. Results revealed a significant presence of protection in the agricultural sector but not statistically commensurate with the share of agriculture to Nigeria's gross domestic product, (GDP). All hypotheses were tested at 1% probability level, i.e. $p < 0.01$. There was a negative significant relationship between agricultural growth and protection in agriculture. A significant and positive relationship exists between agricultural growth and budgetary appropriation to the agricultural sector, while foreign direct investment and farmers' economic welfare had a non-significant and negative relationship with protection level. There was significant causality running from budgetary appropriation (agriculture) to agricultural protection and from protection level to GDP (agriculture). One of the major recommendations is that government should review its policy instruments, programmes, and projects to ensure that targeted policy objectives such as increase in agricultural growth is achieved by increasing its budget and liberalizing the sector.

Keywords: Agricultural protection, agricultural growth, agricultural budget, political economy, Nigeria
JEL: C32, F21, O11, Q14

INTRODUCTION

Nigeria is one of the developing economies with significant expenditures on agricultural protection through interest and exchange rates differentials, price mechanisms, input subsidies, researches, embargos and regulations promulgated in various protectionistic policy reforms, projects and programmes. Before 1980, African economies were deeply confronted with a crisis situation but Nigeria's experience of the economic crisis was delayed until the early - and mid- the 1980s with the collapse of global oil price. Sequel to this, many African countries including Nigeria adopted remedial and protectionistic measures to address their economic problems, either on their own or at the instance of multinational finance/development agencies such as the International Monetary Fund and the World Bank. Such protectionistic measures, policies, reforms, projects, and programmes executed in Nigeria from 1980 include but not limited to Green Revolution in 1980, Directorate of Food, Roads and Rural Infrastructure (DFRRI) in I986, Better Life for Rural Women in 1992, National Agricultural Land Development Authority (NALDA,) in 1992, Family Support programme (FSP) and Family Economic Advancement Programme (FEAP) in 1996, National Fadama Development Project (NFDP) in 1990, National Economic Empowerment and Development Strategy (NEEDS) in 1999, National Special Programme on Food Security (NSPFS) in 2002, Root and Tuber Expansion Programme (RTEP) in 2003 (**Iwuchukwu and Igbokwe, 2012**). Others include the Growth Enhancement Scheme (GES) in 2011 and Agricultural Transformation Agenda (ATA) in 2015 and Agricultural Promotion Policy (APP) in 2016. Each of these reforms consists of one or more of agricultural protection instruments such as tax exemption, tariff reduction, subsidies, credit facilities, reduced interest rate, and regulations and each of them have cost implications.

Agricultural protection is a political economy tool designed to boost domestic production and it is justified not only on the grounds that it can contribute to domestic food security and foster more stable societies, but also because there are sound economic reasons to do so (**FAO, 1999**). One of these sound economic reasons is to increase

GDP in the sector but **Gardner (1992)** allegedly confounded the paradox of growing protection and the declining share of agriculture in his research. Also, worthy to note is that the oil sector which used to contribute a meagre 2.6% of the GDP in 1960, later contributed 57.6% to the GDP in 1970 and up to 99.7% in 1972 (**Keke, 1992**). Agriculture, on the other hand, contributed only 12% to the GDP in 1970 and has remained stagnated till 2017. This supposedly has culminated in rising food import bill leading to the persistent huge deficit in the balance of payments over the years (**Ugwu, 2007, CBN, 2017**). These conflicting claims beg for empirical research and investigation into this paradox of increasing expenditure on protectionistic programmes and decreasing GDP in agriculture.

On the issues of political economy variables that affect protection, **Moon, Pino, and Asirvatham (2016**) theorized that agricultural protection represents an effort by the political class to increase agricultural growth by improving national food security and minimizing food dependence on foreign countries. Rooted in the realist view of the world, the theory suggests that a state's concern about food dependence on foreign countries or about national food insecurity would be heightened as the extent of vulnerability to national food insecurity increases and as per capita income rises. In turn, concern about national food insecurity in a country is hypothesized to lead to growth in agricultural protection. In **Akanegbu (2015**), the pace of economic growth of Nigeria is best indicated by the trend of its gross domestic product (GDP) or gross national product (GNP).

The patterns of agricultural protection policies in Nigeria and other developing economies in Africa suggest that developing nations strongly subsidize agriculture (**Olper, 1998**). However, scholars have conflicting opinions about the impact of such political economy tool because poverty and other expected macroeconomic indexes are not commensurate with the claims of huge expenditures by the political class over the years. For instance, **Inhwam (2008)** and **Barrette (1999)** had argued that agricultural protection is capable of creating negative externalities to developing countries because agricultural protection distorts trades of agricultural products which some developing countries have a comparative advantage in producing. On the contrary, **Goldin and Knudsen (1990)** opined that since agriculture is a sector of comparative advantage for many developing countries now and for some time in future, agricultural protection does not materially impair their potentials for economic growth. **Moon, Pino, and Asirvatham (2016)** also support that protection could bring about agricultural growth in the economy.

To determine the relationship between agricultural growth and protection, some other relevant political economy factors or indicators are expected to guide the decision. **Bratton and van de Walle (1994)** viewed political economy variables as those factors taken into consideration as economic and political exigencies when analysing protectionism. Such political economy variables may include the state of food security or food self-sufficiency status; the contribution of foreign exchange earnings from the sector's export; general economic welfare to farm producers; GDP of the sector; budgetary allocation to the sector; and political or structural changes in the economy. In the same line of thought, **Amin (1972)** explained that different regime reflected varying economic and political interests. It is expected that a nation whose food supply is grossly dependent on import would be politically vulnerable. **Pejout (2010)** opined that food riots and violence became more prevalent in African cities following the rapid escalation of food prices in 2008 **(Pejout, 2010)** and this resulted in political instability and drove governments to re-analyse their agricultural policy. General economic welfare to farmers is also a political indicator that determines the demand push for protection from voters/farmers. It is expected that when the farmers are not making much of profit, their demand for protection may likely increase. Sometimes, it is suspected that political class purposively increases the agricultural budget for protection or subsidies in order to gain political support during elections. In line with this, **Bratton and Van De Walle (1994)**, opined that political class or elite mobilize political support by using their public position to distribute rent-seeking opportunities such as subsidies, interest free-loan, or grants. Nations' GDP appears to be a quick tool in the hands of politicians for measuring the progress of policies and programmes. The GDP situation during a specific period or policy regime may guide the political class on whether the sector needs promotion or not. The rise and growth of agricultural protection coincide with the long-term decline in the share of agricultural labour and in the share of agriculture from overall GDP (**Binswanger and Deininger, 1997**).

Empirically, data from **CBN (2018)**, in the year 1960, agriculture contributed about 64% to the total GDP, however, in the 1970s, the contributions from agriculture to the GDP decreased to 48%. Furthermore, the decrease proceeded to 20% in 1980 and 19% in 1985 respectively and has continued to show weakness till date.

By the opinion of **Iwuchukwu and Igbokwe (2012),** Nigeria's agricultural policies and programmes have undergone changes, especially in the post-colonial era. These changes according to **Amalu (1998)** have been a mere reflection of changes in government and administration. Amalu emphasized that these policies and programmes vary only in nomenclature and organizational network. Maybe no empirical research has bordered to investigate the claim that despite these policies and reforms, which gulped billions of tax-payers money, poverty and poor agricultural growth are still prevailing.

Olawepo (2010) opined that income is generally low from agricultural production. Also, International Fund for Agricultural Development (**IFAD; 2016, NBS; 2017**) reported that despite all these many efforts, poverty is still widespread in the country and has been on increase. Also, **CBN (2018)** reported that the share of GDP from agriculture has remained between 11% and 21% from 1980 to date. In any country where government's intervention is promulgated in any sector, questions of accountability and appraisal arise of to what extent or degree does government support such policy, and how much has the policy contributed to the growth of the sector?

The main objective of this study was to examine the impact of agricultural protection on agricultural growth in Nigeria. The specific objectives were to (i) estimate the level of agricultural protection in Nigeria; (ii) determine the effects of agricultural protection on agricultural growth, and (iii) analyse the causal relationship between agricultural protection and agricultural growth in Nigeria. The null hypothesis tested was that agricultural protection does not have a statistically significant impact on agricultural growth in Nigeria.

DATA AND METHODS

Analytical framework

Studies on agricultural protection or other political economy issues have employed alternative measurement concepts which differ in their meanings and in terms of their uses and degree of complexity. However, where the effects of government policies are not directly translated into domestic prices, these measures would provide only a partial indication of the extent of government's protection interventions. The most simple and widely used measurement of the protection level is the nominal rate of protection (NRP) and the nominal protection coefficient (NPC) (**Tyers and Anderson, 1992; Krueger, Schiff and Valdés, 1991**). **Amin (1996)** puts that Nominal protection coefficient (NPC) is the ratio of producer price (Pi) to the border price (Pf) with adjustment made for transport, storage, and other costs.

Also, the relationship between agricultural GDP and agricultural protection is akin to output and input relation. While government stimulate agricultural production with some protection policy instruments such as fertilizer subsidy, direct transfer, distribution of improved seedling, etc, it is expected that these investment will transform into increase in GDP.

The effect of agricultural protection on agricultural growth was analysed in the standard growth accounting framework. The validity or strength of the multiple linear regression method used in this study is based on the Gauss-Markov assumptions in which the dependent (GDP) and independent variables (political economy/macroeconomic variables) are expected to be linearly correlated, with the estimators (β_0, β_1, β_2, β_3, β_4, β_5) being BLUE with an expected value of zero i.e. $E(\varepsilon) = 0$, which implies that on average the errors cancel out each other.

Model specification

The coefficients of the protection level in the agricultural sector are widely estimated using the nominal protection coefficient (NPC). According **to De Gorter and Tsur, (1991), Krueger, Schiff, and Valdés, (1991)**, the most simple and widely used measurement of the price wedge is the nominal rate of protection (NRP) and the nominal protection coefficient (NPC) **(Krueger, Schiff and Valdés, 1991; Miller and Anderson, 1992 and Arene, 2008).** The level of protection estimation equation is given in Eq. 1.

$$NPC = \frac{PD}{PW} \qquad (1)$$

Where: PD Domestic Producer Price; PW World price.

The measurement concepts refer to the protection levels for a single agricultural commodity, but these can easily be aggregated to reflect overall protection to the agricultural sector. Secondly, to represent the relationships between agricultural output and its political economy determinants, the standard model of economic growth as applied by **Owutuamor and Arene, 2018** was followed. In the same line, **Solow (1956)** growth model was adopted in which the output of agricultural sector, usually measured by the gross domestic product (GDP) of the sector, is represented in the production function where its growth depends on a number of factors X_1, X_2, X_3...X_n. The function is shown in equation 2.

$$Y = f(X_1, X_2, X_3, X_4, X_5) \qquad (2)$$

Where: Y output and X_1, X_2, X_3, X_4, X_5 factors that determine the rate of output. To account for time factor in the model, according to **Mankiw, Romer and Weil (1992),** output i.e. Agricultural GDP growth, became a function of government income (measured by agricultural budget), foreign direct investment (FDI), amount of protection in the sector (measured by nominal protection coefficient, NPC), policy structure changes and form of government at time (t).

$$Y_t = f(X_{1(t)}.X_{2(t)}.X_{3(t)}.X_{4(t)}.X_{5(t)}) \qquad (3)$$

Assuming there is a steady state, say a linear relationship, as seen in standard output models; output is estimated by multiple linear equations in the linear form in Eq. 3, which formed the basis for the estimation of the model in this study. This study is also based on the assumption that there may be other influential factors affecting growth but this study is only restricted to political economy variables as indicators for quick and easy policy considerations. In order to establish the mathematical function of this model, the intercept β_0, measure of error term ε and parameters of estimations $\beta_{1,2,3...n}$ are added in Eq. 4.

$$Y_t = \beta_0 + \beta_1 X_{1(t)} + \beta_2 X_{2(t)} + \beta_3 X_{3(t)} + \beta_4 X_{4(t)} + \beta_5 X_{5(t)} + \varepsilon \qquad (4)$$

Choice of variables

The choice of political economy variables that could affect agricultural protection was conceptualised in line with the views of **Moon, Pino, and Asirvatham (2016**) which theorized that agricultural protection represents an effort by the political class to increase agricultural growth. Rooted in this realist view of the political economy relationship, the study selected only variables assumed to have strong political and economic implications for agricultural policy. These variables stand as indicators in the hands of the political class which guide their political and economic decisions on the timing, budgeting and degree of protection in the sector.

In line with this conceptualisation, **Bratton and van de Walle (1994)** viewed political economy variables as those factors taken into consideration as economic and political exigencies when analysing protectionism. Such political economy variables may include the state of food security or food self-sufficiency status; general economic welfare or GDP of the sector; budgetary allocation to the sector; and policy structural changes in the economy. In the same line of thought, **Amin (1972)** explained that different regime reflected varying economic and political interests. Also, in **Akanegbu (2015**), the pace of economic growth of Nigeria is best indicated by the trend of its gross domestic product (GDP). Following this, the model for the regression as given in Eq. 4 are specified thus:

Y GDP Gross Domestic Product, the dependent variable which represents the GDP share to agricultural sector; an indicator or tool for making quick political decisions for adjustments or performance assessment in the economy.);

X_1 Nominal Protection Coefficient (NPC), used as proxy for measuring the degree of agricultural price protection in the economy;

X_2 Foreign Direct Investment (FDI) share to agricultural sectors which represents the economic and political will of individuals to invest in the sector);

X_3 budgetary allocation to agricultural sector which is an indicator for political willingness of the ruling class to motivate or invest in the economy;

X_4 policy structure changes (protection 1, no protection 0);

X_5 form/type of government (civilian 1, military 0);

β_0 Intercept;

t Time series;

ε Stochastic error term; and

$\beta_1, \beta_2, \beta_3$ Estimation coefficients.

Apriori Expectations: On apriori, the following relationship in line with Eq. 2 as expected is shown in Eq. 5.

$$GDP = f(NPC) \tag{5}$$

In order to improve the linearity of the equation, **Owutuamor and Arene, (2018)** followed same as advised in **Obansa and Maduekwe (2013)** that there is need to log-linearize all the incorporated variables in order to avoid multicollinearity and to revert the mean generating process. As such, natural log is introduced into Eq. (4), thereby giving the econometric model in (Eq. 6).

$$lnY_t = \beta_0 + ln\beta_1 X_{1(t)} + ln\beta_2 X_{2(t)} + ln\beta_3 X_{3(t)} + ln\beta_4 X_{4(t)} + ln\beta_5 X_{5(t)} + \varepsilon \tag{6}$$

The model's empirical strategy is based on these *apriori* expectations shown in Eq. 7.

$$\beta_0 > \beta_1 > \beta_2 > \beta_3 > \beta_4 > \beta_5 \tag{7}$$

The empirical model specified in Eq. 7 was estimated from literature. First, the observed variables, X_1-X_5 are fully accounted for in the equations based on the assumption that agricultural growth does not happen without some factors acting on it (**Inhwan, 2008; Moon, Pino, and Asirvatham, 2016**). However, it is expected that many factors could affect the growth of the sector but this study was limited to political economy perspective. The reason was to specifically x-ray the dynamics of government's interventions in the sector. In line with the assumptions, **Bratton and van de Walle (1994)** opined that political economy variables are those factors taken into consideration as economic and political exigencies. Also, it is expected that increase in NPC in the economy will motivate growth in the sector. Increase in FDI share to agricultural sectors will increase the volume of production and growth. Increase in budgetary allocation to agricultural sector will spur investment and growth. Also, when the policy structure changes from exploitation or liberalization to protection policy, many young investors would feel protected and invest more. Finally, it is expected that government under democracy would attract more investment and growth in the sector.

Hypotheses

The following two hypotheses were tested in the study:

Ho_1: agricultural protection level does not have a significant effect on agricultural growth in Nigeria; and

Ho_2: there is no causal relationship between agricultural protection level and agricultural growth. The null hypotheses, H_0 were tested using the F-statistic at the five percent (5%) level of significance. The calculated F value (Fcal) was compared to the critical value of F (F-tab). Usually, if the value of the F-cal is greater than that of the F-tab at the 5% level of significance; the null hypothesis is rejected but if otherwise, it is accepted. The F-statistics formula is given as Eq. 8.

$$F = \frac{\frac{R^2}{K} - 1}{\frac{1-R^2}{N-K}} \tag{8}$$

The Study Area

The study area is officially known as the Federal Republic of Nigeria, but here often referred to as Nigeria. The major exports of the country are: crude oil (petroleum), natural gas, cashew nuts, skin and fur, tobacco, cocoa, cassava, rubber, food, live animals, aluminium alloys and other solid minerals, **(CIA World Factbook 2018)** while major imports are refined petroleum products, wheat, rice, sugar, herbicides, fertilizers, chemicals, vehicles, aircraft parts, vessels, vegetable products, processed food, beverages, spirits and vinegar, equipment, machines, and tools **(NBS 2015).** Despite its considerable agricultural resources, Nigeria is still a net importer of food and agricultural products in general **(USAID 2009)** and as such the agricultural sector has been one of the least attractive sectors **(Owutuamor and Arene, 2018)** and has lost its leading contribution to Nigeria's GDP **(CBN 2018; FAO 2012).**

Data Specification

This work made use of secondary data. The annual time series data of agricultural output, measured by the share of agriculture to GDP, and FDI inflows into the sector were collected from CBN, spanning from 1980-2015 while 2016 was extrapolated. Also, NPC was calculated from annual data of domestic price collected from FAOSTAT and World price collected from World Bank. This study covering a 37-year period, spanning from 1980 to 2016 employed descriptive statistics aided by the use of Microsoft Excel and inferential statistics in the form of the econometric regression methods of the multiple linear regression and Granger causality test were applied as the estimation technique in evaluating the relationships and causality between the dependent variable (agricultural growth) and the political economy variables (agricultural protection level, foreign direct investment inflows to agriculture, Gross Domestic Product (GDP) inflows from the agricultural sector into the economy, political structure changes in national policy reforms and form of government in power).

The regression equation was estimated after carrying out pre-estimation tests for stationarity in order to avoid multicollinearity of explanatory variables. To eliminate the presence of autocorrelation in the model, this study applied the Augmented Dickey-Fuller (ADF) test to detect the stationarity of the variables at the 5% level of significance and also identify the order of integration of the variables in the model.

For the objective one, the level of protection in agriculture was estimated using the NPC model. For objective two, the effect of protection (as estimated in objective one) and other political economy tools on agricultural growth were determined using multiple linear regression with SPSS. For objective three, the causal relationship between agricultural growth and the independent variables (political economy variables) were determined using Granger causality test with Eview software.

RESULTS AND DISCUSSION

Pre-Estimation Techniques

Before the main analyses were conducted, the set of data was tested for unit root in the study. ADF was used to carry out the test under its traditional conditions, hypotheses and decision rules as adopted by **Nwosu and Okafor (2014)**. In a related study, **Njoku, Chigbu and Akujobi (2015)** also adopted the use of unit root test on some residuals using the ADF test. The variables were further tested for endogeneity and corrections made. Also, the variables were further subjected to cointegration test to check for long-term association.

The decision rule showed that the prob (t-stat) > 0.05 which implied that the null hypothesis of no integration be rejected and we, therefore, concluded that the variables in the model have long-term relationship.

To eliminate the presence of autocorrelation in the model, this study applied the Augmented Dickey-Fuller (ADF) test to detect the stationarity of the variables at the 5% level of significance and also identify the order of integration of the variables in the model. The ADF test was based on the following regression in Eq. (8).

$$\Delta Y_t = \alpha + \beta Y_{t-1} + \delta t + \Sigma ς k \Delta Y_{t-kPk=1} + \varepsilon \qquad (8)$$

H0: δ = 0 (*Y* has no unit root);
H1: δ ≠ 0 (*Y* has unit root)
Where:
Y Variable tested (*lnGDP*, *lnFDI*, *lnBUDGET*, and so on)
α Intercept (constant term)
δt Coefficient on a time trend
β Parameter of the variable in regression
P Lag order
Δ Difference operator.

The **Johansen (1991)** co-integration method was used to test for long-term relationship between the variables. This involves looking for linear combinations of I in Eq. (9) time series that are stationary in the order I(1). This procedure focuses on the rank of the Π-matrix as shown in Eq. (9).

$$\Delta Z_t = \alpha + \Pi Zt - 1 + \Sigma \Gamma 1 \Delta Zt - iP - 1i = 1 + \varepsilon \qquad (9)$$

Where:
Z n x 1 vector of variables that are integrated of order one, often denoted as I(1);
Π co-efficient matrix ;
Γ number of co-integrating relationships.
Such that if the Π-matrix has reduced rank, the endogenous variables depicted by *Z* are co-integrated, with α as the co-integrating vector.
However, if the variables are stationary in levels, Π would have full rank.
The results of the ADF and cointegration tests are shown in Tables 1 and 2. The result shows that all the variables were stationary at their first difference (i.e. 1(1)).

Table 1: ADF unit root test result

Variables	ADF Sats	Critical Value 1%	Critical Value 5%	Critical Value 10%	Order of Integration	Remark
1.GDP	-6.192236	-3.639407	-2.951125	-2.614300	1(1)	stationary
2.NPC	-5.890904	-3.639407	-2.951125	-2.614300	1(1)	stationary
3.FDI	-11.91513	-3.639407	-2.951125	-2.614300	1(1)	stationary
4.BUDGET	-5.550498	-3.639407	-2.951125	-2.614300	1(1)	stationary
5.POCH	-3.657007	-3.657007	-2.967767	-2.622989	1(1)	stationary
6.GOVFORM	-6.692878	-3.632900	-2.948404	-2.612874	1(1)	stationary

Source: computed output with e-views.

Table 2: Johansen cointegration test result

Eigen Value	Likelihood Ratio (Lr)	Critical Value 5%	Hypothesized No Of C.E
0.734822	-	46.23142	None**
0.673258	1464.734	40.07757	At most 1
0.581074	1446.277	33.87687	At most 2
0.5410732	1431.921	25.58434	At most 3**
0.458023	1419.082	21.13162	At most 4**
0.363664	1408.976	14.26460	At most 5*
0.090478	1401.517	3.841466	At most 6**

*(**) denotes rejection of the hypothesis at 5 percent (1 percent) significance levels. L.R. test indicates 5 cointegration equations (s) at 5 percent level. C.E represents Cointegrating Equations
Source: computed output with e-view

The result in the Table 2 confirm that the variables were co-integrated in the long-run at the same rate by the normalized co-integration coefficient with the highest log likelihood in absolute term.

Estimates of Agricultural Protection Coefficient in Nigeria

The level of protection in the agricultural sector in Nigeria (Table 3) shows an unsteady trend. In general, the average coefficient of protection measured from selected major staple food and agricultural export commodities in Nigeria shows that the mean value was 31.8%, the minimum was 19.6% (2009) while the maximum was 53.2% (2000). This suggests that Nigeria protected agricultural sector. This result is in line with previous studies (**Olper, 1998**) which states that the patterns of agricultural policies in Africa suggest that developing nations strongly subsidize or protect agriculture.

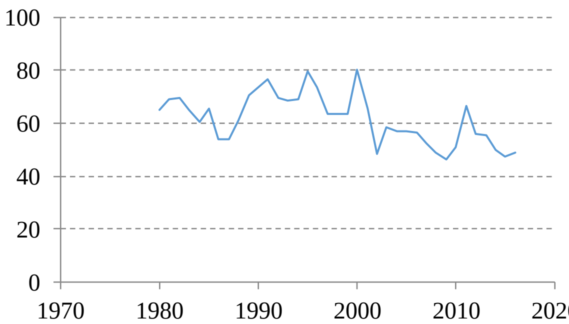

Figure 1: Graphical presentation of protection level in agriculture from 1980 to 2016.
Source: Author's Computation, 2018.

Effects of Agricultural Protection and Other Political Economy Variables on Agricultural Growth

The results in Table 4 showed that about 33.5% variations of agricultural growth were explained by variation in the selected political economy variables which was statistically significant ($p < 0.01$). This means that the variables specified in the model significantly affected the growth in the agricultural sector. As such, the null hypothesis which states that agricultural protection level does not have a significant effect on agricultural growth in Nigeria be rejected, and the alternative hypothesis accepted.

The specific political economy factors that had significant effects on agricultural growth were agricultural protection level, nation's budgetary allocation to Agriculture and form of governance. These political economy variables were discussed below:

Agricultural protection level and agricultural growth

This research reveals that agricultural protection level had negative significant effect on agricultural growth in Nigeria. For every one unit change in agricultural protection level, there is a change of -280 units showing a decrease in the agricultural growth measure - GDP share to agriculture. This is related to other findings by **Saibu and Keke (2014)** and **Usman and Arene (2014)**, who inferred that some macroeconomic variables move in opposite direction. In related studies, **Barrette (1999)** and **Inhwam (2008)** had argued that agricultural protection is capable of creating negative externalities to developing countries. Also, **Ubogu (1988)** conclude that a liberal trade regime with low tariffs and without quotas up to 1973 translated to export-led growth in the world economy and relative stability in Nigeria's export earnings and inflow of foreign capital.

The policy implication of this result is that funding meant for agriculture should rather be used for investment in other areas of the sector other than offering protection to the farmers through subsidies and incentives. The sector is in urgent need for massive investment under liberal trade since this study has shown that protecting the sector would do more harm than good. This result has also revealed that food policy involves not only activities in agricultural production but also includes feeding the industries with raw materials, food processing and manufacturing to reduce post-harvest losses, distribution and marketing of value-added products and, trade and consumption that are capable to spur industrialization.

Budgetary allocation to agriculture

This research reveals that agricultural budgetary allocation had a positive and significant impact on agricultural growth in Nigeria. For every one unit change in agricultural budget, there was a positive change of 2.99% in the GDP share to agriculture showing a significant increase in the agricultural growth. It is logical and expected that a unit increase in budgetary allocation to agriculture causes a positive impact on the growth and productivity of agriculture. This result is in line with that of **Asghar, Hussain and Rehman (2012), Ogujiuba and Ehigiamusoe (2013).** Keynes theory on public expenditure and economic growth regards public expenditures as an exogenous factor which can be utilized as a policy instruments promote economic growth. From the Keynesian's point of view, public expenditure can contribute positively to economic growth.

Table 3: Nominal protection of agriculture in Nigeria from 1980 – 2016.

YEAR	NPC cocoa	NPC cotton	NPC maize	NPC palm oil	NPC rice	NPC rubber	NPC wheat	NPC Average	NPR Average
1980	1.7	2.2	0.6	0.9	1.1	1.1	1.0	1.2	20
1981	1.9	2.2	0.6	1.0	1.1	1.1	1.0	1.3	30
1982	2.0	2.1	0.7	1.0	1.1	1.1	1.0	1.3	30
1983	1.8	2.1	0.6	1.0	1.1	1.1	1.0	1.2	20
1984	1.5	2.1	0.6	1.0	1.1	1.1	1.0	1.2	20
1985	1.4	2.5	0.8	0.9	1.1	1.1	1.0	1.2	20
1986	1.3	2.5	0.9	1.0	1.1	1.1	1.0	1.3	30
1987	1.7	2.0	1.0	1.0	1.1	1.0	1.0	1.3	30
1988	2.0	2.2	1.0	1.0	1.1	1.0	1.0	1.3	30
1989	2.8	2.1	1.0	1.0	1.1	1.0	1.0	1.4	40
1990	3.0	2.1	1.0	1.0	1.1	1.0	1.0	1.5	50
1991	3.1	2.2	1.0	1.0	1.1	1.1	1.0	1.5	50
1992	2.6	2.2	1.0	1.0	1.1	1.1	1.0	1.4	40
1993	2.5	2.2	1.0	1.0	1.1	1.1	1.0	1.4	40
1994	2.7	2.1	1.0	1.0	1.3	1.1	1.0	1.5	50
1995	3.3	2.2	1.0	1.0	1.0	1.0	1.0	1.5	50
1996	2.8	2.3	1.0	1.0	1.0	1.0	1.0	1.4	40
1997	2.3	2.1	1.0	1.0	1.0	1.1	1.0	1.4	40
1998	2.0	2.4	1.0	1.0	1.0	1.1	1.0	1.4	40
1999	2.2	2.2	1.0	1.0	1.0	1.1	1.0	1.4	40
2000	3.3	2.3	1.0	1.0	1.0	1.1	1.0	1.5	50
2001	2.3	2.3	1.0	1.0	1.0	1.1	1.0	1.4	40
2002	1.2	2.1	1.0	1.0	1.0	1.1	1.0	1.2	20
2003	1.8	2.3	1.0	1.0	1.0	1.0	1.0	1.3	30
2004	1.8	2.1	1.0	1.0	1.0	1.1	1.0	1.3	30
2005	1.7	2.2	1.0	1.0	1.0	1.0	1.0	1.3	30
2006	1.7	2.2	1.0	1.0	1.0	1.0	1.0	1.3	30
2007	1.5	2.1	1.0	1.0	1.0	1.0	1.1	1.3	30
2008	1.3	2.1	1.0	1.0	1.1	1.0	1.1	1.2	20
2009	1.0	2.2	1.0	1.0	1.1	1.0	1.1	1.2	20
2010	1.5	2.0	1.0	1.0	1.1	1.0	1.1	1.2	20
2011	2.4	2.2	1.0	1.0	1.0	1.0	1.0	1.4	40
2012	1.7	2.1	1.0	1.0	1.0	1.0	1.0	1.3	30
2013	1.7	2.1	1.0	1.0	1.0	1.0	1.0	1.3	30
2014	1.3	2.1	1.1	1.0	1.0	1.0	1.1	1.2	20
2015	1.1	2.2	1.0	1.0	1.0	1.0	1.1	1.2	20
2016	1.2	2.1	1.1	1.0	1.0	1.0	1.2	1.2	20
Min								1.2	20
Max								1.5	50
Mean								1.3	30

NPC means Nominal Protection Coefficient. Source: Author's Computation, 2018.

Table 4: Parameter estimates of effects of Political Economy Variables on Agricultural Growth

Political Economy Variables	Parameters	Coefficients	t-ratio
(Constant)	β_0	-(.443)	.549
NPC	X_1	-.280 (.061)	-1.786*
FDI	X_2	-.126 (.583)	-.826
BUDGET	X_3	510 (.193)	2.987***
PCH	X_4	-.005 (1.548)	-.030
GOVFORM	X_5	-.371 (2.090)	-2.216

Key: ***, **, * represent 1%, 5% and 1% levels of significance respectively. Figures in parentheses represent standard errors.
Source: Authors' computation, 2018.

The result obtained in the study suggests that agricultural budgets have positive impact on agricultural growth in Nigeria. This suggests that Nigeria has to encourage increased investment and budgetary allocation to the sector. If the investment and budget are increased in the sector, it could support a vibrant agricultural sector capable of ensuring the supply of raw materials for the industrial sector as well as providing gainful employment for the teeming population. It will also address the economic problems of rural poverty which is rampant and reduce dependence on oil and food importation. This call needs urgent attention especially now that Nigeria's poverty rate is reportedly alarming. However, if the agricultural sector is encouraged with the introduction of improved technology so as to diversify the economic base and reduce dependence on oil revenue in the bid to return the economy to the path of self-sustaining growth and industrialization, then it will enhance economic prosperity. **Zietz and Valdes (1993)** also identified that the size of government's budget is likely to shift the supply curve of protection, adding that it's particularly true when agricultural protection is provided through subsidies or incentives. Therefore, caution should be taken to invest the funding in areas that require investment rather than agricultural protection.

Causal Relationship between Agricultural Protection Level and Agricultural Growth

The null hypothesis which states that there is a causal relationship between agricultural protection level and agricultural growth was tested using Granger causality test and the result is presented thus:

Table 5: Parameter Estimates for short run Pair Wise Granger Causality Tests between level of agricultural protection and growth in the sector.

Null Hypothesis	F-Statistic	Prob.
GDP does not Granger Cause NPC	14.9167	0.0005
NPC does not Granger Cause GDP	11.8675	0.0016

Sample: 1, 36 , Lags: 1

Source: Authors Computation, 2017.

The result showed that the null hypotheses contained in Table 5 were rejected. These, therefore, mean that GDP share from agriculture causes significant changes in agricultural protection and that in the short run too, protection level in agriculture is significant in causing changes in GDP growth share from agriculture. This is related to that of **Obansa and Maduekwe (2013), Oloyede (2014),** and **Owutuamor and Arene (2018)** that agricultural growth can be induced by a macroeconomic variable. Since GDP can be used to measure general economic welfare in an economy **(Gardner, 2012), Bratton and van de Walle (1994),** opined that political class or elite mobilize political support by using their public position to distribute rent-seeking opportunities such as subsidies, interest free-loan, or grants. This means that when the GDP is low, politicians are likely to increase agricultural protection as a way of buying support from farmers who are also the majority of the voters. Paradoxically, the increase in agricultural protection causes a negative change in the sector's GDP as seen in the regression in Table 5.

CONCLUSIONS

This study was carried out to statistically analyse the impact of agricultural protection on agricultural growth, measured by agricultural output (GDP) in Nigeria. The variables were logically restricted to political economy indicators as tools in the hands of the political class for managing the economy of the nation. It describes the trends in agricultural growth and protection level in agriculture and empirically analysed the effects of agricultural protection level on gross domestic product inflows from agricultural sector into the economy and other political economy cum macroeconomic variables such as Foreign Direct Investment (FDI) share to the agricultural sector which represents the economic and political will of individuals to invest in the sector; budgetary allocation to agricultural sector which is an indicator for political willingness of the ruling class to motivate or invest in the economy; political structure changes whose dummy nature was vectorized into protection as 1, and no protection as 0; and form/type of government (also put as civilian 1, military 0).

The empirical results show that about 34 percent of the total variation in agricultural growth can be explained by agricultural protection and other political economy variables considered in the model, whereas less than 66 percent is accounted for by the error term and other variables not included in the political economy model. Although there was a negative relationship between agricultural growth and protection in agriculture, this was significant. It also reveals that agricultural protection had a positive and significant impact on agricultural growth in Nigeria between 1980 and 2016.

The findings in this study suggest strong policy implications which are recommended as thus: Nigerian government should rearrange its food policies to position agriculture in a more liberalized commercial form as a serious business rather than a means of addressing farmer's demand for subsidies and price effects. The government should also increase its budgetary allocation to the sector for the purpose of embarking on the massive construction of agro-industries, silos, and other important capital projects that would cover many other aspects of agriculture such as processing, storage, marketing, industrialization, etc.

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REGULAR ARTICLE

DISCOVERY OF MAIZE PRICE AND FOOD CROP MARKET DYNAMICS IN NIGERIA

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ABSTRACT

Having the mandate of achieving food security in Nigeria, commendable efforts have been geared towards food production in the nation. Albeit the increasing production, price volatility has continued to perpetuate in food markets in Nigeria hence attaining food affordability, a precondition for food security, remains a mirage. An innovative approach to the food challenge therefore, may be to understand the food markets dynamics such as to gain insight into how the market works. In this study we focus on maize, a very important staple in Nigeria. We seek to identify the point of price discovery and markets that significantly influence price of maize. In furtherance, we examine the dynamic relationship existing among the markets and explored the responsiveness of the markets to price signals from the other markets. Our results showed that most of the markets examined behave in such a manner expected of open market however full market integration has not been achieved. It was revealed that prices of maize are discovered from major food market in the deficit production zone. Majority of the markets were responsive to one-time price shock from itself, although exhibiting exogeneity in the contemporaneous period but becoming endogenous by the long run (whereby other markets majorly influenced prices) hence indicating that the markets had commendable informational influence on one another. The study therefore recommended installing infrastructure for linkage of production with the demand zones if price stabilization is to be achieved. Regulatory bodies should also check activities of cartels in the influential markets.

Keywords: Agricultural Markets, Food crop, Impulse response function, Nigeria, Price discovery, Variance decomposition
JEL: L1, Q11, Q13

INTRODUCTION

With rising population, the challenge of how to feed the additional mouths has continued to stare nations in the face given the recognition that food security remains a key component of stability in any economy. Over the years, food security has drawn so much attention globally and in fact, at the World Food Summit of 1996, governments reaffirmed the right to food and committed to halving the number of hungry and malnourished from 840million to 420million in 2015. Statistics has shown the world has failed horrendously to achieve this objective seeing that the hungry has grown in excess of 1billion globally as at 2012 (**Conway, Wilson and Shah,2012**) The *Right to Food*, derived from the International Covenant on Economic, Social and Cultural Rights (of the **United Nations Treaty Collection**) in May 2012 saw many States signing a covenant to direct efforts at taking steps to the maximum of their available resources to achieve progressively the full realization of the right to adequate food both nationally and Internationally. Although, empirical evidence suggests that Africa is one of the continents with the biggest food problems globally, it cannot be concluded that the continent is one that has geared inadequate efforts towards solving her food crisis. Nigeria, the most populous nation in Africa has over the years come up with various strategies and programmes directed at curtailing food price volatility and invariably the attainment of food security.

Based on a study by **Olomola (2015),** these may be classified as short, medium and long-term measures. The short-term measures involve release of grains from the National reserves in order to crash the prevailing prices; mopping up operations entailing the buying of food stock from local stores followed by sales of these foods to consumers at subsidized rates; distribution of small-scale machines targeted at assisting the local farmer/producers and also the waiver of tariffs to stimulate private sector into food imports such as to raise supply and lower market prices eventually. Medium terms measures were as well taken and some of these involve the allocation of 1.68 percent of the federal budget to the Natural Resources Development Fund during 2008–11 for boosting the domestic production of food crops, the development of the agro-allied industry, and research and development (RandD) on seed varieties; provision of agricultural funds as a credit scheme at a concessionary interest rate; completion of all outstanding National Food Reserve storage facilities; while the long term measures were harness in the nation's food security strategy document which has policy thrust along the line of value chain approach to agricultural development, commodity focus in providing support to producers, successor farmer generation, provision of safety nets for producers.

These efforts are logically appealing, to the benefit of Africa as a whole because an imminent food crisis in Nigeria, with the size of its population, will be a regional disaster for neighbouring African countries if they have to be a source of relief and asylum to that effect. Various agricultural indices have shown the evolvement of food production in Nigeria, supported in expansion of hectarage, higher yields and of course increasing production. Albeit, food prices in Nigeria has continued to be volatile which is a constraint to food affordability and invariably food security in the nation. Most of the policy measures and approaches taken towards stabilizing food prices have proven to be unsustainable. According to **Díaz-Bonilla (2016)**, this is mostly caused by fiscal costs, the distortions generated in production and trade when not using market prices, and the usually inequitable distribution of costs and benefits.

Tsimpo and Wodon (2008) linked the constantly rising price of staples in developing countries to low domestic production, seasonal production variability, high transaction cost, inefficient markets and a high reliance on imports. **Olomola (2015)** ascribe the escalating food prices in Nigeria to demand pressures from neighbouring countries some of which have experienced food riots, substitution effect of the 2008 food crisis and the high cost of transportation in due to rising cost of petrol being imported. Nigeria is among many African countries that have engaged in agricultural liberalization since 1986 in the hope that reforms emphasizing price incentives will encourage producers to respond. Hitherto, the reforms seem to have introduced greater uncertainty into the market given increasing rates of price volatility **(Ajetomobi, 2010)**. Being characterized by the dominance of resource-poor individuals not only in the production but also in the marketing arm of agriculture, the volatility in pricing of agricultural commodities has far reaching implications for majority of the players in the industry.

One innovative way to approach the food challenge, therefore, may be to understand the market having established that increased production as a strategy has failed to be the magic wand in enhancing food access. Gaining insight into the nuances, operationality and dynamics in food crop markets in Nigeria becomes pertinent. In this study, we lay emphasis on the grain subsector given its importance **(Awoyemi *et al.*, 1986; Balami, Ogboru and Talba, 2011; Bio, Dahuri and Roger, 2015)** and we focus on Maize which is justified by the fact that it is one of the most common staples and one mostly traded in Nigeria, likewise having multiplicity of use as food, in agribusinesses, brewery, pharmaceuticals, exportation, bio-fuels and consequently, with capacity to indirectly impact on the employment level in the nation **(Ihimodu, 2007; Matthew and Ben, 2016; Mansharamani, 2012; Maziya-Dixon, Akinyele, Oguntona, Nokoe, Sanusi and Harris, 2004)**. To reconnoitre the Nigerian domestic grain markets, this study was designed to: identify the point of price discovery and markets that significantly influence price of maize; examine the dynamic relationship existing among the markets; and explore the responsiveness of the markets to price signals of maize in the other markets. Gaining insight into price and market dynamics will be smoothening out the existing information asymmetry hence better positioning market players towards more galvanized and sustainable food markets system in Nigeria. The study was carried out in Nigeria, a country consisting of 36 states and the Federal Capital Territory, Abuja. Located in West Africa on the Gulf of Guinea, Nigeria has a total area of 923,768 km2 (356,669 sq. mi). Nigeria, Africa's most populous country is one of the ten most populous countries in the world. The population is growing rapidly, rising from 88.9 million in 1991 to 140 million in 2006 and 193.4 million in 2017 **(NPC, 2017)** and about 70% of the population are engaged in agricultural production albeit at subsistent levels **(World Bank, 2015)**.

DATA AND METHODS

Data description and Sampling Procedure

Panel data for this study include prices of the selected food crop, maize, which were primarily sourced over a period of 52 weeks from 24 markets across 11 states and the FCT in Nigeria between September 2015 and August 2016. Modal prices of maize were collected in each of the selected market on a weekly basis through market enumerators and these were cross-verified from traders and buyers in the marketplace in order to authenticate the veracity of the collected data. For the purpose of monitoring the enumerators, spot checks were made as unscheduled visits to various market locations during the course of the study. Contacts were also established with various traders at the initial visitation to all the selected states during sampling of traders and random calls to them which further served as a means of ensuring reliability of the weekly price data being collected by enumerators. A four-stage sampling procedure was engaged to select the 24 markets earlier stated. Stage one involved the stratification of the states in Nigeria based on the agro-ecological zones. States that overlapped in terms of multiple agro-ecological zones were pooled together and eventually there were two strata. The first stratum includes Mangrove/Fresh water swamp/Rainforest zones while the second stratum includes Short grass guinea savanna/Marginal savanna woodland/Tall grass savanna zones. The second stage involved the random and proportionate selection of 30% of the States in each stratum. Four States were selected from the first stratum while seven States were selected from the second stratum to give a total number of eleven (11) states. This was done with a level of approximation. The Federal Capital Territory was purposively selected alongside the eleven states to give total of twelve (12) locations. The third stage involved both purposive selection of the major food crop market in the state capital and random selection of one rural food crop market from each of the twelve (12) selected locations. Information on the market listing was sourced from The States' Ministry of Commerce and Trade.

Theoretical framework

In this study, we theorize that food crop markets being investigated may be seen as the individual level whereas it is expected that some form of interrelationships exists amongst the various food markets in the economy on the overall which tends to bunch and determine how the prices flow. Firstly, we define market as a system, institutions, procedures, social relations and infrastructures whereby parties engage in exchange and this is the process by which the prices of goods and services are established. While parties may exchange goods and services by barter, most markets rely on sellers offering their goods or services (including labour) in exchange for money from buyers. Markets facilitate trade, enable the distribution and allocation of resources in a society while also allowing any trade-able item to be evaluated and priced.

As explained explicitly by **Kirzner (1963)**, a market exists whenever the individual members of a society are in sufficiently close contact to one another to be aware of numerous such opportunities for exchange and, in addition, are free to take advantage of them. Furthermore, a market economy exists wherever the ramifications of the market become so widespread and the opportunities it offers so numerous and attractive that most individuals find it advantageous to carry on their economic activities predominantly through the market rather than on their own. The market economy is thus to be distinguished, on the one hand, from the autarkic economy, where individuals carry on their economic activity isolated from one another, being unaware or unwilling to take advantage of opportunities for exchange. On the other hand, it is to be distinguished from the centrally controlled economy where economic activity of individuals is directed by a central authority so that, although transfers of goods among individuals may be ordered by the central authority, individuals are not free to take advantage of exchange opportunities which they themselves may perceive.

All actions connected to the notion of the market can be traced back to one single type of action which is exchange. In other words, this may be regarded as the buying and selling goods and services. Exchange is voluntary and mutually beneficial or else it would not take place **(Buchanan and Tullock 1965). Gauthier (1986)** stated that the market nexus is free from violence in a narrow sense and at least by tendency, also free from all considerations of solidarity. Market participants are neither enemies nor friends. Systematically, the market players regard each other just with regard to their abilities and skills, in their capacity to deliver something regarded as useful therefore, they regard each other just as a link in the chain **(Wicksteed 1933).** According to **Thielmann (2000)**, in market exchange, as far as it is motivated solely by considerations of efficiency and advantage, participants treat each other as means. The other is able, having the power to contribute efficiently, or else will be excluded. Therefore, market exchange, as such, is not constituted by inter-subjectively sharable meanings or reasons.

During any given period, therefore, the decisions made by individual market participants constitute an interlocking system embracing the entire scope of the market. This network of decisions constitutes the market system. The end results of all these decisions make up the achievements of the market system; and the tasks which society may seek to fulfil by permitting a market economy are the assigned functions of the market system **(Kirzner, 1963)**. The expectation of economists and market participants from the activities that go on in the market is such that the markets can be said to be efficient. Such efficiency is tied to how well the markets are integrated and how fast information on the commodity pricing are able to get transmitted and circulated within and among markets. It is expected that if transportation costs and economic barriers are taken off from markets, each commodity should have a uniform price that cuts across all the markets. This phenomenon is referred to as the Law of One Price which is an economic theory positing that a good must sell for the same price in all locations. This law is derived from the assumption of the inevitable elimination of all arbitrage **(Góes and Matheson, 2015; Mankiw 2011)**. The law of one price is otherwise known as the Fundamental law of one price identity (FLOPI). Assuming P^L and P^C denote the prices of a food crop in Markets L and C respectively with the corresponding transport and transactions costs to taking the food crop from market C to L is P^{Tc}. Then the law of one price adjusted for transport and transaction costs implies the equilibrium known as the law of one price which is stated as Equation 1.

$$P^L = P^C + P^{Tc} \Leftrightarrow \frac{P^L}{P^C + P^{Tc}} = 1 \qquad (1)$$

In case the two markets both produce and can trade a commodity in either direction the law of one price states that the price difference should be smaller or equal to transport and transaction costs. FLOPI then is smaller or equal to one. If the price difference is larger than transport and transaction costs, trade will close the gap. There are possibilities that the local demand and supply conditions in two markets may be such that price differences are smaller than transport and transaction costs and there will not be any need for trade in which case both markets are somewhat self-sufficient **(Persson, 2008)**.

According to **Fan and Wei (2005)**, the law of one price implies that the prices for the same product sold in different markets tend to converge to the same level due to profit incentives and market forces. In mathematical terms, the convergence to the law of one price for a product means that the time series of its relative prices is mean-reverting or stationary. Moreover, there may be significant costs of transportation and transaction in inter-regional trade, which complicates the dynamics of price convergence. Indeed, the issues of market integration and the law of one price are central to the very foundation of the discipline of economic.

The intuition behind the law of one price is based on the assumption that differences between prices are eliminated by market participants taking advantage of arbitrage opportunities **(Persson, 2008)**. Assume different prices for a single identical good in two locations, no transport costs and no economic barriers between both locations. The arbitrage mechanism can be performed by both the supply and/or the demand site: All sellers have an incentive to sell their goods in the higher-priced location, driving up supply in that location and reducing supply in the lower-priced location. If demand remains constant, the higher supply will force prices to decrease in the higher-priced location, while the lowered supply in the alternative location will drive up prices there.

Conversely, if all consumers move to the lower-priced location in order to buy the good at the lower price, demand will increase in the lower-priced location, and assuming constant supply in both locations - prices will increase, whereas the decreased demand in the higher-priced location leads the prices to decrease there **(Persson, 2008)**. Either of the scenarios mentioned will result in a single, equal price per homogeneous commodity in all locations **(Lamont and Thaler, 2003)**. The law of one price also defines the extent of the market and measures market integration **(Stigler and Sherwin, 1985)**. If a single price exists over several spatially separate markets, it implies that these markets are integrated as a single market. Measurement of market integration can be viewed as basic to understanding how specific markets work **(Ravallion, 1986)**.

According to **Persson (2008)**, perfectly efficient set of markets will allow only very short violations of the law of one price however, this is too strong a condition to be of practical significance. There are always local shocks which will take time to get diffused to other markets and distortions of information will make global shocks affect local markets differently. How long violations can persist depends on the state of information technology, whether markets operate with inventories and how competitive markets are. In furtherance to this, it was also stated that convenient econometric way of analysing the nature of the law of one price as an "attractor equilibrium" is an innovation correction model of the error terms which is meant to estimate an equilibrium law of one price. If markets are not well integrated one cannot establish or estimate FLOPI. Given the existence of a long-run or equilibrium price relationship between markets, a violation is known as "innovation" or shock, which will be corrected for so that the equilibrium price difference is restored. The innovation correction model is usually expressed in differences of log prices and the error correction model in this case may be stated as Equation 2.

$$\Delta P_t^L = \alpha^L \ln\left(\frac{P_{t-1}^L}{P_{t-1}^C + P_{t-1}^{TC}}\right) + \varepsilon_t^L$$
$$\Delta P_t^C = \alpha^C \ln\left(\frac{P_{t-1}^L}{P_{t-1}^C + P_{t-1}^{TC}}\right) + \varepsilon_t^C \qquad (2)$$

The price shocks or innovation is mostly shown in an innovation correlation matrix and usually, the magnitudes of the parameters are an indicator of the efficiency of the markets. The higher they are, the faster will the equilibrium law of one price (FLOPI) be restored and the more efficient the markets being investigated are. Cointegration is one of the tests for law of one price and this was as employed in this study in order to establish the integration of the Nigerian agricultural markets modelled.

Model Specification

Our model follows the work of **Vitale and Bessler (2006)**, in which case we seek to identify the points of price discovery and markets that significantly influence prices of maize. This analysis was approached through a (cointegrated) Vector Auto Regression model in which Directed Acyclic Graphs (DAGs) are used to sort out causal flows of price information in contemporaneous time.

Based on apriori knowledge that prices in a free market are non-stationary and which has been established on the series worked on. Then let, X_t denote a vector which includes the weekly prices (52 observations) from each of the 24 markets that were sampled, and this vector can be modelled in an error correction model stated as Equation 3.

$$\Delta X_t = \prod X_{t-1} + \sum_{i=1}^{K-1} \Gamma_i \Delta K_{t-i} + \mu + e_t \qquad (3)$$

Where, $t = 1,2,3 \dots \dots T_i$, $E(e_t e_t' = \Omega$ is positive finite, Π and Γ are parameter matrices to be estimated, μ constant, e_t white noise innovation term

Equation (3) is synonymous to a vector autoregression (VAR) model in first differences but for the presence of the lagged levels of X_{t-1}. There are three possible outcomes in this estimation and each of these has various implications as follows:

1. If Π is of full rank, then X_t is stationary in levels and a VAR in levels is an appropriate model.
2. If Π has zero rank, then it contains no long run information and the appropriate model will be a VAR in first difference.
3. If Π has a rank of positive number r, which is less than p (where $p =$ number of series i.e. 24 markets, then there exist matrices α and β, with dimensions p by r, such that $\Pi = \alpha\beta^1$ in which case $\beta^1 X_t$ is stationary even though X_t is non-stationary.

From literature **(Sims, 1980; Swanson and Granger, 1997** and **Vitale and Bessler, 2006)**, the dynamic price relationships can best be summarized through the moving average representation. The estimated form of equation (3) may be algebraically expressed as a levels VAR from which point the moving average representation for it is solved. The X_t is written as a function of the infinite sum of past innovations (Eq.4).

$$X_t = \sum_{i=0}^{\infty} G_i e_{t-1} \qquad (4)$$

Where G_i is a 24 by 24 matrix of moving average parameters which map historical innovations at lag i into the current position of the vector X. According the **Vitale and Bessler (2006)** after whom this work is being modelled, the matrix G_0 is generally not the identity matrix as the elements of the vector e are usually not orthogonal as there may be non-zero correlation between contemporaneous innovations hence analysis of Equation (4) without making some adjustment for non-orthogonal innovations may not reflect the dynamic historical patterns present in the data.

It is more desirable to work with a transformed moving average representation on orthogonalized innovations (Eq. 5).

$$v_t = A_{et} \tag{5}$$

where, A is such that $E(v_t v_{t^1}) = D$ and $D$is a diagonal matrix.

The next step in the procedure involves the application of directed acyclic graph algorithms to place zeros on the A matrix.

From the estimated form of equation (4), the vector X in terms of the orthogonalized innovations may be stated as Equation 6.

$$X_t = \sum_{i=0}^{\infty} \Theta_i V_{t-i} \tag{6}$$

(whereby the vector X is written as an infinite series of orthogonalized innovations, V_{t-i})

Graph theory and PC algorithm are then used to determine the causal pattern behind the correlation in contemporaneous innovations. A directed graph is a pictorial representation of the causal flow among variables. Usually, lines with arrowheads are used to represent flows such that $A \longrightarrow B$ indicates that variable A causes variable B. In a situation whereby the line connecting two variables for instance $E - F$, does not indicate any arrow direction, then it implies the two variables E and F are connected by information flow however there is no knowledge as related to causal relationship between the variables. According to **Pearl (2000)**, the fundamental idea that allows us to detect direction of causal flow to a set of (observational) variables is that of screening-off phenomena and their more formal representations as d-separation. For three variables A B and C, if we have variable A as a common cause of B and C so that $B \leftarrow A \longrightarrow C$, then the unconditional association between B and C will be non-zero, as both have a common cause in A and this type of diagram is labelled a causal fork according to **Pearl (2000)**.

Vitale and Bessler (2006), stated that if one measure association (linear association) by correlation then B and C will have a non-zero correlation. However, if one conditions on A, the partial correlation between B and C (given knowledge of A) will be zero as knowledge of the common cause (A) "screens-off" association between its effects (B *and* C).

On the other hand, considering variables D, E and F such that $D \longrightarrow E \leftarrow F$. It implies that E is a common effect of D and F and this diagram is labeled a causal inverted fork **(Pearl 2000)**. D and F will have no association (zero correlation if the relationship is constrained to linear association); however, if one conditions on E, the association between D and F is non-zero (the partial correlation between D and F, given knowledge of E is non-zero) and it can be said that knowledge of the common effect does not "screen-off" association between its causes **(Vitale and Bessler, 2006)**. **Vitale and Bessler (2006)** stated further that in case of variables G, H and I forming a causal chain, $G \longrightarrow H \longrightarrow I$, the unconditional association (correlation) between G and I will be non-zero, but the conditional (partial) correlation between G and I, given knowledge of G and H, will be zero. **Spirtes, Glymour and Scheines (2000)** and **Pearl (2000)** present algorithms with similar structures and outputs for inference on directed acyclic graphs from observational data.

In order to examine the dynamic relationship existing among the selected markets, the Impulse response function was applied to the fitted Vector Autoregressive model to enable one interpret and describe the reactions of dynamic system existing in each of the modelled market to external changes resulting from the other markets that parameterize the dynamic behaviour of the entire system. This exhibit result in the form of how price in each of the market responds to a one-time-only shock on every other sampled market price. Based on explanation by **Rossi (2010)**, it may be stated that the impulse response function traces the effect of an exogenous shock or innovation in one of the markets on all the other markets modelled in this study and thereby supplying information of the types of causality that exist in the modelled markets.

The impulse response function can be stated as the Eq. 7.

$$y_{t+n} = \sum_{i=0}^{\infty} \Psi_i \, \epsilon_{t+n-i} \tag{7}$$

where., $\{\Psi_n\}_{i,j} = \frac{\partial y_{it+n}}{\partial \epsilon_{jt}}$ with the response of $y_{i,t+n}$ to a one-time price shock or impulse in $y_{j,t}$with all other markets dated t or earlier held constant. The response of price in market i to a one-time price shock in market j is mostly depicted graphically to have a visual impression of the dynamic inter-relationships within the system whereas the percentages were as well generated in a tabular form.

According to **Ronayne (2011)**, the Impulse response function is a powerful new analytical weapon offered by the VAR methodology. Impulse response functions are used to track the responses of a system's variables to impulse of the system's shocks. **Ronayne (2011)** stated that the standard Impulse response function uses estimation from the estimated VAR model. This methodology of generating of Impulse response functions involves non-linear (at horizon greater than one) functions of the estimated VAR parameters. Ronayne further stated that the order of the polynomial increases as the horizon shifts even higher. Given that the horizon is fixed at 1, the VAR will produce the optimal one-step ahead forecast. **Stock and Watson (1999)** even stated that despite a misspecification of model, a VAR process will still produce reliable one-step ahead forecast.

The graphs indicate a broad pictorial representation which may easily be understood while the tabular form states the percentages associated with each of the graphs. The impulse responses are zero if price in one of the markets does not granger cause prices in the other markets in the modelled system whereas, an innovation in price in market *k* has no effect on the prices in other markets. In other words, market *k* price does not granger cause the set of remaining markets within the modelled system.

In exploring the responsiveness of each of the selected markets to price signals of Maize in the other markets, the Forecast Error Variance Decomposition was applied to partition the price uncertainties in each market at different time periods in order to reveal how each market responded to externalities in price signals. The Forecast error variance decomposition measured the contribution of each shock type to the Forecast error variance and determined the quantity of the Forecast error variance of each of the markets that could be explained by exogenous shocks to the other markets.

Lütkepohl (2007) stated that in econometrics and other applications of multivariate time series analysis, a variance decomposition or forecast error variance decomposition (FEVD) is used to aid in the interpretation of a vector autoregression (VAR) model once it has been fitted.

According to **Zivot and Wang (2006)**, forecast error variance decomposition answers the question: what portion of the variance of the forecast error in predicting $y_{i,T+h}$ is due to the structural shock η_j

Using the orthogonal shocks η_t the h-step ahead forecast error vector, with known VAR coefficients, may be expressed as Equation 8.

$$Y_{T+h} - Y_{T+h|T} = \sum_{s=0}^{h-1} \Theta_s \eta_{T+h-s} \qquad (8)$$

Whereas, for a particular variable $y_{i,T+h}$, the forecast error is of the form indicated in Equation 9.

$$y_{i,T+h} - y_{i,T+h|T} = \sum_{s=0}^{h-1} \Theta_{i1}^{s} \eta_{1,T+h-s} + \dots + \sum_{s=0}^{h-1} \Theta_{in}^{s} \eta_{n,T+h-s} \qquad (9)$$

Since the structural errors are orthogonal, the variance of the h-step forecast error may be written as Equation 10.

$$\mathrm{var}\left(y_{i,T+h} - y_{i,T+h|T}\right) = \sigma_{\eta 1}^2 \sum_{s=0}^{h-1} (\Theta_{i1}^{s})^2 + \dots + \sigma_{\eta n}^2 \sum_{s=0}^{h-1} (\Theta_{in}^{s})^2 \qquad (10)$$

Where $\sigma_{nj}^2 = var\,\eta_{jt}$. The portion of $var(y_{i,T+h} - y_{i,T+h|T})$ due to shock η_j is therefore stated in Equation 11.

$$FEV\,D_{i,j}(h) = \frac{\sigma_{\eta j}^2 \sum_{s=0}^{h-1} \left(\Theta_{ij}^{s}\right)^2}{\sigma_{\eta 1}^2 \sum_{s=0}^{h-1} \left(\Theta_{i1}^{s}\right)^2 + \dots + \sigma_{\eta n}^2 \sum_{s=0}^{h-1} \left(\Theta_{in}^{s}\right)^2}, \quad i,j = 1, \dots, n \qquad (11)$$

Zivot and Wang (2006) further stated that Forecast error variance decomposition largely depends on the recursive causal ordering used to identify the structural shocks η_t and is not unique therefore different causal orderings will produce different FEVD values.

Some underlining information in the report on Forecast Error Variance Decomposition in this study is the fact that a market may be regarded as being exogenous or endogenous at a point in time on the basis of how much proportion of the market's uncertainty is being explained by other markets being sampled alongside the market. In a situation whereby a large proportion of the forecast error decomposition is accounted for by other markets, then the market is taken to be an endogenous one which implies the market is a dependent market. However, when only a minimal proportion of the forecast error decomposition of that market is accounted for by other markets, then the market under scrutiny is taken to be an exogenous one, in other words such a market is independent.

Another important note to the tabular report given on the Forecast Error Variance Decomposition as well as the corresponding points on the graph is that there are ten variance periods indicated in the report with these representing the weeks under investigation. Variance period one indicates the contemporaneous time while variance periods two, five and ten signify the short run, intermediate run and the long run respectively. It is worthy to note that summation of all the observations across each of the variance periods will give an approximate value of One hundred percent which as well explains the percentage as indicated on the graphs.

RESULTS AND DISCUSSION

Table 1 presents the results for the Augmented Dickey Fuller unit root test carried out on levels and first differences of maize prices in each of the market over the sampled period. The unit root test on maize prices in all of the markets revealed that prices were non-stationary at levels. However, they became stationary after first differencing i.e. I(1) in sixteen of the selected market and these were the markets on which further analyses were carried on. Lagos urban market was specifically excluded from the analysis as price of maize remained on the same level over the period of data collection.

Table 2 presents a series of Trace tests for co-integration carried out on the investigated markets. The results presented indicate the Unrestricted Co-integration Rank Test using the trace statistics as shown with the corresponding result associated with the number of co-integrating vectors and the decisions to reject (R) or Fail to reject (F) the null hypothesis on the number of co-integrating vectors ($r = 0, r \leq 1, \dots, r \leq 15$) at a 5% level of significance.

The result of Trace test revealed the first failure to reject the null hypothesis (denoted by F#) was observed at thirteen co-integrating vectors. This implies that thirteen long run stationary relations are present in the markets that were investigated. While thirteen long run stationary relations are present in the sixteen markets modelled, it is likely that price in some of the markets will not be a part of the identified thirteen long run relations.

In furtherance to the test of co-integration, test on exclusion was carried out which is meant to exclude each of the markets from the co-integration space and then observe which of the markets exist or do not exist in the co-integration space. Table 3 presents the result of Test on exclusion as carried out.

Table 1: Summary of Augmented Dickey Fuller (ADF) Tests of non-stationarity carried out on prices (at level) and first differences of maize prices from twenty-four Nigerian markets in year 2015-16

S/N	Market		Levels			First Difference		
			t-stat	p value	Lag	t-stat	p value	Lag
1	Kwara	Onile aro oloogun(R)	-1.9568	0.6103	0	-5.2969	0.0004	0
2	Kwara	Ago (U)	-0.8964	0.9484	0	-6.6345	0.0000	0
3	Abuja	Genge pada (R)	-1.7554	0.7112	1	-5.9145	0.0001	0
4	Abuja	Wuse (U)	-1.1278	0.9140	0	-5.3699	0.0003	0
5	Kano	Garun Baba (R)	-2.4779	0.3374	0	-5.3489	0.0003	0
6	Kano	Dawanou (U)	-2.4166	0.3670	0	-4.3965	0.0051	0
7	Kaduna	Kasarami (R)	-0.1548	0.9924	0	-6.2705	0.0000	0
8	Kaduna	Kawo (U)	-0.2982	0.9887	0	-5.6082	0.0001	0
9	Nasarawa	Odapu ogaji (R)	-3.1327	0.1102	1	-5.6274	0.0001	1
10	Nasarawa	Alamis (U)	-2.5782	0.2915	0	-4.7252	0.0020	0
11	Imo	Umugunwa (R)	-2.2535	0.4508	0	-5.9818	0.0000	0
12	Imo	Eke-Onunwa (U)	-2.0761	0.5463	0	-6.0424	0.0000	0
13	Lagos	Garafa (R)	-2.2356	0.4603	0	-6.3566	0.0000	0
14	Lagos	Mile 12 (U)	-	-	-	-	-	-
15	Ogun	Odeda (R)	-3.5673	0.0429	0	-7.2344	0.0000	0
16	Ogun	Kuto (U)	-2.9717	0.1500	0	-8.4369	0.0000	0
17	Oyo	Kogijo (R)	-2.2117	0.4730	0	-6.7511	0.0000	0
18	Oyo	Bodija (U)	-1.3956	0.8505	0	-6.8827	0.0000	0
19	Osun	Ogba-agba (R)	-2.3837	0.3833	1	-5.2012	0.0005	0
20	Osun	Igbona (U)	-1.8159	0.6824	0	-7.1649	0.0000	0
21	Anambra	Afo Mbaukwu (R)	-2.6309	0.2690	0	-8.2681	0.0000	0
22	Anambra	Eke-Awka main(U)	-2.8051	0.2022	0	-6.9687	0.0000	0
23	Enugu	Ugwuokpa (R)	-0.8818	0.9501	0	-7.9258	0.0000	0
24	Enugu	Ogbete main (U)	-1.2834	0.8809	0	-9.0452	0.0000	0

Source: Data analysis, 2016

Table 2: Test of co-integration among Prices for Maize from Nigerian Markets in 2015-16

Hypothesized No. of CE(s) H0: r	Eigen value	Trace Statistic	Critical Value(0.05)	Prob.**	Decision
None	0.999446	1416.719	NA	NA	R
At most 1	0.982171	1041.815	NA	NA	R
At most 2	0.954641	840.4685	NA	NA	R
At most 3	0.942513	685.8113	NA	NA	R
At most 4 *	0.86893	543.0011	334.9837	0	R
At most 5 *	0.83642	441.4	285.1425	0	R
At most 6 *	0.771805	350.8773	239.2354	0	R
At most 7 *	0.699296	276.9996	197.3709	0	R
At most 8 *	0.61388	216.9182	159.5297	0	R
At most 9 *	0.577102	169.3378	125.6154	0	R
At most 10 *	0.545605	126.3067	95.75366	0.0001	R
At most 11 *	0.487624	86.86729	69.81889	0.0012	R
At most 12 *	0.395632	53.43245	47.85613	0.0137	R
At most 13	0.287704	28.25386	29.79707	0.0745	F#
At most 14	0.201611	11.29075	15.49471	0.1942	F
At most 15	0.000656	0.032806	3.841466	0.8562	F

Note: **MacKinnon-Haug-Michelis (1999) p-values
Source: Data analysis, 2016

Table 3 presents the results in which each of the sixteen markets under investigation was excluded from the co-integration space and the null hypothesis was that the respective market excluded was not in the co-integration space with the test being the distributed Chi Squared with thirteen degree of freedom as zero is being associated with markets in each of the vectors and where R indicates rejection of the null hypothesis while F indicates failure to reject the null hypothesis in which case the null hypothesis that the particular market is not within the co-integration space is accepted. The result is presented both for a lag order of one and two. However, the findings were quite similar in both cases.

From Table 3, it can be seen that there was failure to reject the null hypothesis of exclusion on price from both rural and urban markets in Anambra and Ogun States, Ogbete urban Enugu market, Igbona urban market in Osun and Kogijo rural Oyo market. Of all the markets identified as not being in the co-integration space, Kuto market in Ogun State and Afo-mbaukwu market in Anambra State have particularly high exclusion with the p-values of 0.620722 and 0.545312 respectively. It is of particular interest to mention observation during data collection which pointed out that these markets had high influx of patronage from Lagos and Port Harcourt cities respectively. Likewise, the regions are not large producers of maize and do not meet their market demands through local production. The prices in these market locations may therefore be an indication of not only occurrences within the localities but rather related trading activities with the mentioned.

VAR Granger Causality otherwise known as Exogeneity Wald test was carried out as an additional test in the empirical analysis to gain more understanding of the dynamic patterns among the markets, and the results is as presented in Table 4. The Exogeneity wald test is meant to establish if a causal relationship exists between each of the market which is in turn made a dependent variable and all other fifteen markets made independent variables. The test was run singly for each of the excluded markets and also for the whole group of fifteen excluded markets against the market made an endogenous variable. The null hypothesis for the VAR granger causality test in this case is that the lagged prices in the fifteen other markets excluded cannot jointly granger cause prices observed in the one market taken as the endogenous or dependent variable.

As shown in the result on Table 4, there is a failure to reject null hypotheses in the cases of both rural and urban markets in Anambra and Ogun States, Garafa rural market in Lagos and Kogijo rural Oyo market. This implies that for these six markets, the null hypothesis that the lagged prices in the fifteen other grouped markets excluded cannot jointly granger-cause prices observed in the each of the market, having taken it as the endogenous or dependent variable was accepted. This is consistent with the results from the Test on exclusion previously carried out which suggested that these markets were not in the same co-integration space as the other markets. For all other cases, the null hypotheses were rejected which implies that prices in each of those markets were actually jointly granger caused by the lagged prices in the fifteen other markets as the case may be.

Table 3: Test on Exclusion of Each of the Sixteen Nigerian Markets from the Co-Integrating Space

		Lag 1			Lag 2		
Location	Market	Chi-squared test	p-value	Decision	Chi-squared test	p-value	Decision
Anambra (R)	Afo Mbaukwu	14.71894	0.545312	F	14.06876	0.593591	F
Kwara (U)	Ago	34.79363	0.004241	R	30.18074	0.017087	R
Anambra (U)	Eke-Awka main	19.25873	0.255475	F	9.711507	0.881254	F
Oyo (U)	Bodija	64.68123	8.36e-08	R	39.8374	0.000822	R
Imo (U)	Eke-Onunwa	27.8198	0.033222	R	53.02829	7.47e-06	R
Lagos (R)	Garafa	26.9967	0.041520	R	14.33067	0.574094	F
Osun (U)	Igbona	19.64058	0.236847	F	43.36785	0.000246	R
Kaduna (R)	Kasarami	74.88773	1.37e-09	R	32.45511	0.008720	R
Kaduna (U)	Kawo	74.19816	1.82e-09	R	33.26572	0.006813	R
Oyo (R)	Kogijo	20.92093	0.181570	F	8.962775	0.914939	F
Ogun (U)	Kuto	13.70443	0.620722	F	16.78386	0.399715	F
Ogun (R)	Odeda	16.75299	0.401752	F	11.61963	0.769723	F
Nasarawa (R)	Odapu ogaji	85.80656	1.47e-11	R	53.61998	5.98e-06	R
Enugu (U)	Ogbete main	20.41302	0.202192	F	11.29694	0.790797	F
Enugu (R)	Ugwuokpa	47.82385	5.06e-05	R	22.6643	0.123008	F
Imo (R)	Umugunwa	172.836	0.000000	R	189.2457	0.000000	R

Source: Data analysis, 2016

Table 4: VAR Granger Causality /Block Exogeneity Wald Test on the Sixteen Nigerian Markets Modelled for Maize Prices

Location	Market	Chi-squared test	p-value	Decision
Anambra (R)	Afo Mbaukwu	37.89108	0.1526	F
Kwara (U)	Ago	59.64901	0.0010	R
Anambra (U)	Eke-Awka main	19.11181	0.9376	F
Oyo (U)	Bodija	93.60662	0.0000	R
Imo (U)	Eke-Onunwa	102.755	0.0000	R
Lagos (R)	Garafa	35.04237	0.2411	F
Osun (U)	Igbona	89.40328	0.0000	R
Kaduna (R)	Kasarami	56.42893	0.0024	R
Kaduna (U)	Kawo	45.88211	0.0319	R
Oyo (R)	Kogijo	15.99802	0.9828	F
Ogun (U)	Kuto	38.17905	0.1452	F
Ogun (R)	Odeda	43.37316	0.0543	F
Nasarawa (R)	Odapu ogaji	98.53122	0.0000	R
Enugu (U)	Ogbete main	72.12059	0.0000	R
Enugu (R)	Ugwuokpa	110.2792	0.0000	R
Imo (R)	Umugunwa	352.2356	0.0000	R

Source: Data analysis, 2016

Table 5. Innovation correlation matrix, $Corr(\varepsilon_t)$

	AFO	AGO	AWKA	BOD	EKE	GAF	IGB	KAS	KAW	KOG	KUT	ODE	ODP	OGBE	UGW	UMU
AFO	1.000															
AGO	-0.144	1.000														
AWK	0.071	-0.089	1.000													
BOD	0.012	0.154	-0.042	1.000												
EKE	-0.135	-0.131	0.295	0.156	1.000											
GAF	0.284	0.284	-0.266	0.277	0.129	1.000										
IGB	-0.223	0.439	-0.205	-0.330	-0.354	-0.092	1.000									
KAS	0.400	-0.263	0.143	0.074	0.208	0.196	-0.472	1.000								
KAW	0.095	-0.388	0.073	0.072	0.056	0.068	-0.188	0.589	1.000							
KOG	0.310	-0.340	0.151	0.406	0.069	0.232	-0.504	0.391	0.192	1.000						
KUT	-0.139	0.163	-0.140	0.300	0.020	0.466	-0.203	0.261	0.067	-0.021	1.000					
ODE	-0.290	0.447	-0.529	0.124	-0.491	0.169	0.138	-0.273	-0.293	-0.157	0.269	1.000				
ODP	-0.015	0.196	-0.124	0.208	0.161	0.329	-0.055	-0.066	0.196	0.118	-0.059	0.379	1.000			
OGB	-0.018	0.468	-0.080	-0.158	-0.605	0.268	0.355	-0.283	-0.338	-0.025	-0.043	0.376	-0.223	1.000		
UGW	0.361	-0.242	0.044	-0.350	-0.066	0.151	-0.097	0.186	0.166	0.243	-0.260	-0.391	-0.134	0.172	1.000	
UMU	-0.262	0.287	0.236	0.207	0.604	0.144	-0.324	0.001	0.011	-0.171	-0.066	0.065	0.440	-0.213	-0.159	1.000

The innovation correlation matrix, $Corr(\varepsilon_t)$ (Table 5) indicating the contemporaneous correlation between the error terms, otherwise known as innovations, from the estimated error correction model in each of the sixteen markets modelled.

From the correlation matrix shown in Table 5, the least correlation can be observed between Eke-Onunwa urban market in Imo and Ogbete main market in Enugu. This is particularly interesting considering the close proximity of these two States and the fact that one would expect free flow of market information that should lead to price innovations. On the other hand, focus group discussion and observation during the data collection period indicated the strong influence of Port Harcourt, Rivers State on markets in Owerri municipal and other neighbouring markets. Commodities are generally more expensive in Rivers State which most residents attributed to the presence of a lot of oil production and oil servicing industries coupled with the limited availability of arable land for agricultural production and the low level of involvement in agricultural production. This has consequently placed higher pressure on such neighbouring States as Imo State whereas the state is not exactly a surplus region for crops such as maize but rather still dependent on Northern traders for the bulk of their grains supply. Another pair of market with similarly low correlation is Odeda rural market in Ogun State and Eke-Awka main market in urban Anambra State. This may be ascribed in part to the distance of these market pairs and then largely to the fact that Odeda rural market may not be expected to have such influence on other markets considering the low marketing activity going on in the rural market. Interestingly, the innovation correlation between Odeda rural and Kuto urban markets in same Ogun State does not exceed 0.269 which is an indication that both markets are not exceptionally correlated despite being in the same State. Igbonna urban market in Osun State and Kogijo rural market in Oyo State likewise indicates low correlation, with a value of -0.504, ranking third least correlation among the markets examined. Based on experiential knowledge from the survey period, one may attribute this low correlation to the bad road network and the poor telecommunication facilities which hinder the free flow of market information and even goods among these markets despite the fact that both states are in the same region. On the other hand, traders in Igbona market mostly buy products from farm gates in Osun State before proceeding to patronize Bodija markets and then in certain cases the Northern market. In this case, price information is more likely to be influenced by these points of purchases.

Eke-Onunwa urban and Umugunwa rural markets in Imo State exhibited the largest innovation correlation with a value of 0.604 while the next largest innovation correlation may be found between Kawo and Kasarami markets which are the urban and rural markets sampled in Kaduna State. Kawo and Kaduna are surplus regions for maize exhibiting very low market prices for the commodity. The good road networks and telecommunication services between these markets may be instrumental to the high level of correlation between the pair. However, there exist well-structured assemblage processes which likely ease the flow of market information between the areas.

It is particularly interesting to note that there is a reasonably high level of innovation correlation between Ago urban market in Kwara and Ogbete main market in Enugu State. Based on observation during the survey period, there are large numbers of Eastern traders in Ago market. Although most of these individuals deal in textile products, one may not completely rule out their instrumentality in relaying market and price information to traders in Enugu and other Eastern markets as a way of letting them know the dynamics of the grain markets considering that Kwara is regarded as a gateway to the North. An innovation correlation of 0.466 can be observed between Kuto urban market in Ogun State and Garafa rural market in Lagos State which may be attributed to the proximity of the state and the free flow of information which allows the market pair to sort of influence each other. Umugunwa market in Imo State and Odapu Ogaji market in Nasarawa State indicated an innovation correlation of 0.440. One may likely attribute this to the fact that Nasarawa State and Imo State are both bound in between by Kogi State, making Nasarawa State the closest Northern State to Imo State where they are likely to access price information and even commodities. Prices of maize in Eke-Awka main market, an urban market in Anambra State showed relatively low innovation correlation with all other maize prices in the sixteen markets under investigation as no innovation correlation observed for this market exceeded 0.295.

PC algorithm was applied to the correlation stated in equation 12 in order to generate the Directed Acyclic graphs to sort out the causal flow on innovation from the Error correction Model on Maize prices from the sixteen markets modelled for maize in this study and the result is as revealed in Figure 1 which presents the Directed Acyclic Graphs indicating the pattern of causal flow on maize price innovations.

It may be gathered from the directed acyclic graphs on maize which is presented in Figure 1 that the prices of maize are discovered from Bodija market in urban Oyo State. Oyo State is not a spectacular producer of maize especially when compared to the production going on in Northern Nigeria. Bodija market is however a major food commodity hub in South-western Nigeria. A phenomenal level of transaction goes on in the market and again the market has the most structured and functional market association of all the sampled market in this study. There are high demands for grains in Bodija market and traders from a considerable number of other states do make purchases from Bodija which results in the high grains demand in the markets. That prices are discovered from Bodija market is an indication of how significant the market is in terms of the commodity pricing in Nigeria.

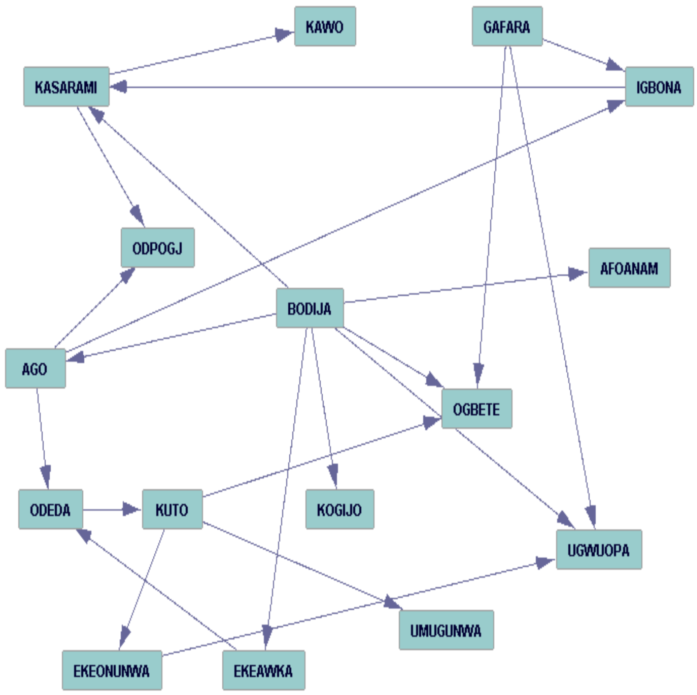

Figure 1: Pattern of causal flow on price innovations among the modelled Nigerian markets for maize
Source: Data analysis, 2016

The dynamic relationship existing among the maize markets modelled were observed in the impulse response function result (full result available as supplementary materials available on request to authors). The result revealed each market to be responding to price shocks from itself. This is however untrue in the case of Umungwa rural Imo State market which did not respond in any form to price shocks from itself. Some other markets that did not indicate any profound response to price shocks within self-include Kawo urban Kaduna market, Kuto urban Ogun market and Odapu ogaji market in Nasarawa State.

Odeda rural market in Ogun State could be seen to strongly respond to price shocks from all the other markets with the exception of Umungwa market in Imo State. No market responded to price shocks from Umungwa market in Imo State which implies that the prices of maize in the market does not particular get transmitted to other markets. This might be an indication that the area has an insufficient supply of maize and may be a deficit region in terms of production. Intense changes in market price are seen not to affect Kawo urban Kaduna market, Kogijo rural Oyo market, Kuto urban Ogun market and Eke awka market in Anambra State.

Kawo market in Kaduna is a very big wholesale and international market and of course a surplus region with so much inter-country transactions going on as traders from outside Nigeria patronise the market. It may therefore mean that Kawo market may be responding to price shocks resulting from such trading with other countries more than the observations made on the other fifteen markets being modelled in this work. On the other hand, the scale of production of maize in this region is indeed massive making the region a surplus region which may not readily react to shocks from lower production regions.

The case of Eke awka market being not too responsive to price shocks may be explained by the fact that the area is a deficit region. It is important to mention at this point that white maize is better accepted by consumers in the region than the yellow maize considered in this research work. It may therefore be accounted for that the deficit position in both production and consumption of yellow maize in the region results in the unresponsiveness of the market to price shocks from other markets examined. Kogijo rural Oyo and Kuto urban Ogun market are also low producers of maize and this may account for the non-responsiveness observed as Kuto depends on Bodija for the bulk of its supply while Kogijo produce in barely enough quantity to supply the rural populace. Likewise, the poor road and communication infrastructure may be shielding information from getting transmitted between Kogijo and other markets modelled in this study. Price shocks from Ogbete main market in Enugu State brought about very minimal responses in all other markets with the exception of itself and Ugwuopa rural Enugu market. This implies that a one-time price shock innovation from Ogbete main market only got responded to by markets sampled within the State which may be as a result of proximity hence ease of information passing among the traders.

The Forecast Error Variance Decomposition was used in interpreting the Vector Autoregressive model in order to be able to explore how responsive the selected markets were to maize price (full result available as supplementary materials available on request to authors). Overall, the markets examined for maize price in this study revealed that all the markets, with the exception of Umungwa market in Imo State, are dependent on maize price information generated from within each of the market itself in the contemporaneous time. Some of the markets however still indicated the presence of price externalities at different levels. Kogijo Oyo market, Odeda Ogun market, Ogbete and Ugwuopa Enugu markets indicated that they were dependent on price information generated within them. These markets generated about 49%, 39%, 36% and 38% respectively and no other market exhibited interference with their price information up to the percentages each generated from within. The only market which indicated a striking position in this maize study in contemporaneous time is Umungwa Imo market which generated about 25% of its price information whereas Eke awka Imo market generated about 37% which apparently exceeds what is generated by Umungwa market itself.

One may make the submission that markets are dependent on maize price information generated from within each individual market itself in contemporaneous time which is an indication that instantaneous causal relations seem to be weak in majority of the sampled markets which means that traders may not have enough time to access market information, process the market information or see the need to even seek nor deploy such information in that time period. It may also be a pointer to the dearth of market infrastructures in the markets. This implies that the risk being generated from causal relationship among the markets is quite low in the contemporaneous time.

It could be gleaned that in the short-run the markets still largely retained the sort of behaviour exhibited in the contemporaneous time, however, Umungwa market in Imo got even further higher influences from Kuto market in Abeokuta and Eke onunwa Imo market with either of them generating even more price information than that generated by Umungwa market itself. It may therefore be concluded that fifteen of the sixteen markets modelled in this study were still exogenous at this point since they were independent of price information in other markets.

By variance period 5 which is taken as the intermediate run, changes have occurred in market and up to 43.75 percent of the markets have become endogenous. The seven markets that became endogenous exhibited that other markets in the series supplied to them even more than the price information generated within the market. The top four markets that distinctly stood out in terms of how they generated price information within them include Afo mbawkwu, Bodija, Eke awka and Garafa markets with these markets generating 56.18%, 56.04%, 64.0% and 40.71% respectively from within itself.

These are particularly interesting points because at this intermediate run, most of the other markets have completely lost potency to generate price information within itself but rather other market gave information exceeding what they generated themselves. Instances are the case of Igbona rural market in Osun State which generated 11.65% of price information from within itself whereas Ago urban market in Kwara and Garafa rural Lagos market generated 26.5% and 25.39% of market information for the market. Also, Bodija market generated 32.18% of the price information in Ago market whereas Ago market generated 29.9% of price information from within itself. Kogijo rural Oyo market at the intermediate run was barely able to generate 13.95% of its price information whereas Bodija urban Oyo market generated 42.14% of market information for Kogijo which is more than three hundred percent of what Kogijo generated from within itself. This implies information is freely flowing between the markets at this point. This may be accounted for by proximity considering that they are in the same state. Bodija urban Oyo market was also observed to generate price information of 28.22% and 35.36% to Ogbete main market and Ugwuopa markets both in Enugu State whereas those markets generate 13.98% and 9.10% of price information from within themselves. At the same intermediate run, Umungwa market generated the least information within itself at a value of 3.04% whereas other markets exceedingly generated information for it.

One may conclude that in the intermediate run, price information had the opportunity to freely flow among most of the markets. This could mean that information had moved through various mediums which are less speedy but have eventually reached out among the markets. In these markets in the intermediate run therefore, one may conclude more price risk is generated by the total of information coming from all other markets than from within themselves. So far in this study, it appears that the most price disrupting information comes from Bodija urban market in Oyo State

The case of Bodija, Afo mbaukwu and Eke awka markets is still particularly interesting as they appear to have been able to shield themselves from market information from other markets. Bodija may indeed be explained based on the information garnered during survey which indicated the presence of strong market cartels which sort of give them an edge when it comes to product pricing from the Hausa traders while also shielding their market from intrusions. Bodija market appeared to be somewhat difficult to penetrate and would not completely pass for an "open market" even though it seems to be one. The grains marketers have devised various informal strategies that prevent free entry and exit to the grain markets particularly even though these are not clearly defined anywhere.

The impact of new information from Bodija market over the other markets sampled in this study becomes even more prominent in the long run. Bodija can be observed to have more effects on price changes across the regions, the most maize-surplus market in the Northern Nigeria inclusive. No single market generated price information for Bodija market that exceeded the information it generated from within it. However, the only market that generated somewhat large information for Bodija market is Kasarami rural Kaduna market which generated 18.93% whereas Bodija market generated 37.06% of price information from within the market itself.

Bodija market likewise generated 30.86% of the price information within Ago urban Kwara market whereas Ago market generated only 14.67% of price information from within. In furtherance, Bodija market was observed to generate price information of 39.80%, 35.86%, 24.76% and 17.43% to the prices of maize in Kogijo, Eke awka

Anambra, Ugwuopa and Kasarami Kaduna markets respectively. This may be put in perspective considering the listed markets generated 11.28%, 39%, 4.22% and 26.35% respectively to its price information from within the market.

Bodija is the largest grain trading markets in South-western Nigeria and with most of the commodities traded in coming from Northern Nigeria. The market also has the most structured market association. The market is strategically placed and with very good road networks linking it to several locations in Nigeria cum the presence of good market infrastructure and telephony services. The grain traders in the market are also mostly educated, seasoned and experienced in the business with some of these individuals running generational trade. These may account for why Bodija market has a dominant effect above other markets in directing prices of maize. This finding is consistent with the VAR granger causality test which revealed that the Bodija was highly significant in causing prices in the other markets given the chi-squared value of 98.53.

The other markets modelled in this study appear to only acquire little information from Umungwa Imo market and Ugwuopa Enugu market even though these markets are indicated to be statistically important by Granger's tests hence these econometric tests exhibited multiple causal relations on prices of maize which may be sort of inconsistent but the findings from the forecast error variance decomposition variance have better reliance.

CONCLUSIONS

Most of the markets investigated in this study were found to behave in such a manner expected of an open market given that the prices were non-stationary at levels. This implies to a large extent, that interference has been truly removed from the market as should be in this post liberalization era. Furthermore, the integration observed in these spatially segregated markets suggests the extent to which the markets have been liberalized which is revealed as not being fully integrated given that the 16 markets modelled were related in 13 co-integrating relationships whereas 15 would have been expected ideally. Prices of maize are discovered from Bodija markets in South-western Nigeria hence it may be concluded that prices are discovered from the excess demand zones. Majority of the markets were revealed to be responsive to one-time price shock from itself, albeit exhibiting exogeneity in the contemporaneous period but becoming endogenous by the long run (whereby other markets majorly influenced prices) hence indicating that the markets had commendable informational influence on one another. Having established that prices are discovered in the excess demand zone, the study recommended that there should be adequate marketing infrastructures such as good roads and communication networks that improve linkages of these areas with the excess supply zone to facilitate price stabilization. Linkage is key because low production zones have pivotal roles to play in price stabilization, guaranteeing farmers in producing areas get good recompense and of course in improving the welfare of farmers, traders and consumers. The roles of marketing associations cannot be overemphasized hence it should be encouraged by the local government as a way of having traders in groups that gives them access to better price information. Transmission of such price information to the association delegates will assist in giving the information a wider reach. This however needs to be done with genuine intentions to ensure that associations do not get hijacked by a few lobbyists that may end up distorting the market.

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REGULAR ARTICLE

ECONOMIC EFFICIENCY OF SMALLHOLDER FARMERS IN WHEAT PRODUCTION: THE CASE OF ABUNA GINDEBERET DISTRICT, WESTERN ETHIOPIA

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ABSTRACT

Yield enhancement through increasing efficiency in cereal production in general and in wheat production in particular could be an important way towards achieving food security. This study was aimed at estimating the levels of technical, allocative and economic efficiencies of smallholder wheat producers; and to identify factors affecting efficiency of smallholder farmers in wheat production. A two stages sampling technique was used to select 152 sample farmers to collect primary data pertaining of 2016/17 production year. Both primary and secondary data sources were used for this study. Stochastic production frontier approach and two limit Tobit model was employed. The stochastic production frontier model indicated that input variables such as mineral fertilizers, land and seed were the significant inputs to increase the quantity of wheat output. The estimated mean values of technical, allocative and economic efficiency were 78, 80 and 63% respectively, which indicate the presence of inefficiency in wheat production in the study area. A two-limit Tobit model result indicated that technical efficiency positively and significantly affected by sex of the household head, education, extension contact, off/non-farm activity and soil fertility but negatively affected by land fragmentation. Similarly, age, education, extension contacts and off/non-farm activity positively and significantly affected allocative efficiency. In addition, economic efficiency positively and significantly affected by sex, age, education, extension contact, off/non-farm activity and soil fertility. The policy measures derived from the results include: expansion of education, strengthening the existing extension services, establish and/or strengthening the existing off/non-farm activities and strengthening soil conservation practices in the study area.

Keywords: economic efficiency, Ethiopia, smallholder, stochastic frontier
JEL: D24, D62

INTRODUCTION

Agriculture is a centre driver of Ethiopian economy. Economic growth of the country is highly linked to the success of the agricultural sector. It accounts for about 36.3% of the Gross Domestic Product, provides employment opportunities to more than 73% of total population that is directly or indirectly engaged in agriculture, generates about 70% of the foreign exchange earnings of the country and 70% raw materials for the industries in the country (**UNDP, 2018**).Even though it is contributing a lot to the Ethiopian economy, the agricultural sector is explained by low productivity, caused by a combination of natural calamities, demographic factors, socio-economic factors; lack of knowledge on the efficient utilization of available; and limited resources, poor and backward technologies and limited use of modern agricultural technologies (**WFP, 2012**). Moreover, the sector is dominated by smallholder farmers that are characterized by subsistence production with low input use and low productivity, and dependency on traditional farming and rainfall.

In sub-Saharan Africa, Ethiopia is the second largest producer of wheat, following South Africa. Wheat is one of the major staple and strategic food security crop in Ethiopia. It is the second most consumed cereal crop in Ethiopia next to maize. It is a staple food in the diets of several Ethiopian, providing about 15% of the caloric intake (**FAO, 2015**), placing it second after maize and slightly ahead of teff, sorghum, and enset, which contribute 10-12% each (**Minot *et al.*, 2015**).It has multipurpose uses in making human foods, such as bread, biscuits, cakes, sandwich, etc. Besides, wheat straw is commonly used as a roof thatching material and as a feed for animals (**Mesfin, 2015**).

In Oromia region, the total area covered by wheat was 898,455.57 hectare produced by 2.21 million smallholders with the total production of 2.66 million tons; and average productivity was 2.96 ton/ha (**CSA, 2017**). In Abuna Gindeberet district, about 22,020 hectares of land was covered by cereal crops. Of these, 6,240 hectares of land was covered with wheat with total production of 174,721 quintals. Despite its increase in area and production, its productivity is low (2.8ton/ha) which is below the average of productivity in the region (2.96ton/ha). There was also variation of productivity among wheat producers in the district due to difference in inputs application rates and management practices like timely sowing.

Production in efficient way is the basis for achieving overall food security and poverty reduction objectives particularly in major food crops producing potential areas of the country **(Tolesa *et al.*, 2014).** However, farmers are discouraged to produce more because of inefficient agricultural production and efficiency differences among producers **(Degefa *et al.*, 2017)**. When there is inefficiency; attempts to commence new knowledge may not result in the expected impact since the existing knowledge is not efficiently utilized. The presence of inefficiency not only limits the gains from the existing resources, it also hinders the benefits that could arise from the use of improved inputs. Hence, improvement in the level of efficiency will increase productivity by enabling farmers to produce the maximum possible output from a given level of inputs with the existing level of technology **(Geta *et al.*, 2013; Yami *et al.*, 2013; Sisay *et al.*, 2015).**

Many researchers, in different sectors, have done many efficiency estimation studies in Ethiopia. However, the majority of farm efficiency studies are limited to technical efficiency (**Fekadu and Bezabih, 2008; Yami *et al.*, 2013; Beshir, 2016; Kelemu and Negatu, 2016; Assefa, 2016; Tiruneh and Geta, 2016).** But, focusing only on technical efficiency (TE) understates the benefits that could be derived by producers from improvements in overall performance. Unlike technical efficiency, studies conducted on economic efficiency (EE) of wheat are limited (**Solomon, 2012; Awol, 2014).** Moreover, there is no study done on economic efficiency of smallholder wheat producers in the study area. Therefore, the objectives of our study was to measure farm level technical, allocative and economic efficiencies of smallholder wheat producers and to identify factors that affect the level technical, allocative and economic efficiencies of smallholder wheat producers in Abuna Gindeberet District.

DATA AND METHODS

Description of the Study Area

The study was conducted in Abuna Gindeberet district in Ambo zone, Oromia National Regional State. The district is located at 184 km west of the capital city of the country, Finfinne. It is bordered by Meta Walkite district in East, Gindeberet district in West, Jeldu district in South and Amhara National Regional State in North. The total land area of the district is 138,483.25 hectares which comprised 41 rural kebeles. Data collection for the study was carried out in three rural kebeles, viz., Jemmo feno, Gitire and Irjajo (Figure 1).

Sampling Technique and Sample Size Determination

Two stages random sampling procedures was employed to draw a representative sample. In the first stage, three kebeles out of the fifteen wheat producing kebeles in the district were randomly selected. In the second stage, 152 sample farmers were selected using simple random sampling technique based on probability proportional to the size of wheat producers in each of the three selected kebeles. To obtain a representative sample size, the study employed the sample size determination formula given by **Yamane (1967)** (Eq. 1).

$$n = \frac{N}{1+N(e^2)} \qquad (1)$$

Where:

n sample size; N total number of wheat producing household heads in the district (5,344) ; e margin error (8%)

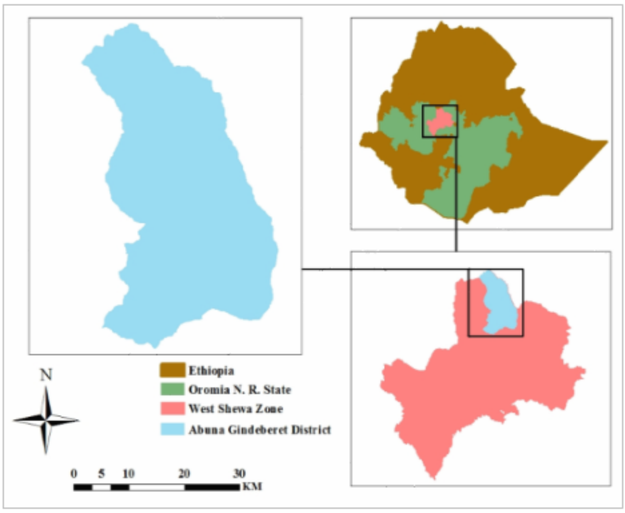

Figure 1. Map of the study area

Data Collection

Both qualitative and quantitative data were used. Data was obtained from both primary and secondary data sources. The primary data were collected using structured questionnaire that was administered by the trained enumerators. The questionnaire was pre-tested and necessary corrections were made before actual use. Secondary data were also collected from bureau of agriculture of the district and other relevant sources.

Methods of Data Analysis

Both descriptive and econometric methods were used to analyse the data. Descriptive statistics, mean, minimum, maximum and standard deviations were used.

Most empirical studies on efficiency in Ethiopia were analysed using stochastic production frontier methodology (**Solomon, 2014; Ahmed *et al*, 2015; Sisay *et al.*, 2015).**This study also employed stochastic frontier approach to estimate the level of technical, allocative and economic efficiencies. The main reason is that stochastic approach allows for statistical noise such as measurement error and climate change which are beyond the control of the decision making unit.

Following **Aigner *et al.* (1977**) the model is specified by Eq. 2.

$$ln(Y_i) = F(X_i, \beta_i) + v_i - \mu_i \qquad i = 1,2,3 \ldots N \quad (2)$$

Where:
i denotes the number of sample households;
$ln(Yi)$ denotes the natural log of (scalar) output of the i[th] households;
X_i represent a vector of input quantities used by the i[th] households;
β_i denotes a vector of unknown parameters to be estimated;
v_i is a symmetric component and permits a random variation in output due to factors beyond the control of farmers. It is assumed to be independently and identically distributed $N \sim (0, \sigma^2{}_v)$ and
u_i intended to capture inefficiency effects in the production of wheat measured as the ratio of observed output to maximum feasible output of the i[th] farm. It is assumed to be independently and identically distributed as half-normal, $u \sim N(u, \sigma^2{}_u)$. The study computes TE for the i[th] firms as Eq. 3.

$$\text{TE} = \frac{lnY_i = \beta_o + \sum_{j=1}^{5} \beta_j lnX_{ji} + v_i - u_i}{ln\,Y_i = \beta_o + \sum_{j=1}^{5} \beta_j lnX_{ji} + v_i} = \frac{Y_i}{Y_i{}^*} \qquad (3)$$

The value of TE lies between zero and one implying fully technically inefficient and fully technically efficient respectively. Following **Battese and Coelli (1995)** the stochastic cost frontier function was specified which forms the basis of computing AE and EE of wheat production. The dual cost frontier is specified as in Eq. 4.

$$ln[\![(C)]\!]_i) = \beta_o + \sum_{j=1}^{5} \beta_j\, lnP_{ji} + v_i + u_i \qquad (4)$$

Where:
ln C_i denotes the logarithm of the cost of production of the i[th] firm;
P_{ji} denotes a vector of inputs price and output of i[th] firm;
β_o, β_j denotes a vector of unknown parameter to be estimated;
v_i denotes random variables assumed to be independent and identically distributed random errors with zero mean and variance (σv^2) and
u_i denotes non-negative random variables which are assumed to account for cost inefficiency.

After we estimate cost efficiency, allocative efficiency is computed as the inverse of cost efficiency. Economic efficiency was computed by the product of technical and allocative efficiencies.

Determinants of efficiency

In this study, to identify the effect of independent variables on level of efficiencies, two-limit Tobit model was employed. Because of the character of the dependent variable which is efficiency score that takes values between 0 and 1 the model is appropriate (**Maddala, 1999**).

Following **Maddala (1999)** the model can be specified as in Eq. 5.

$$y^*_{i\,TE,AE,EE} = \delta_0 + \sum_{n=1}^{12} \delta_n Z_{in} + \mu_i \qquad (5)$$

Where: i refers to the i[th] farm in the sample households; n is the number of factors affecting efficiencies scores; y_i is efficiency scores of the i[th] farm. y_i^* is the latent variable, δ_n are unknown parameters to be estimated and μ_i is a random error term that is independently and normally distributed with mean zero and common variance of $\sigma^2(\mu_i \sim \text{IN}(0, \sigma^2))$. Z_{in} are demographic, institutional, soci-economic and farm-related variables which are expected to affect the dependent variable (level of efficiencies in this study).

Denoting *yi* as the observed variables (Eq. 6),

$$y_i = \begin{bmatrix} 1 & if\;\; y_i^* \geq 1 \\ y_i^* & if\;\; 0 < y_i^* < 1 \\ 0 & if\;\; y_i^* \leq 0 \end{bmatrix} \qquad (6)$$

Since the distribution of the explained variable in equation (5) is not normal the ordinary least square (OLS) estimation will give biased estimates **(Maddala, 1999).** To avoid the biased estimates arrives from OLS, the maximum likelihood estimation can give up the reliable estimates for unknown parameters. Following **Maddala (1999),** the likelihood function of this model is given by Eq. 7.

$$L(\beta, \delta | y_{j,} X_j L_{1j,} L_{2j}) = \prod_{y_j = L_{1j}} \varphi\left(\frac{L_{1j} - \beta' X_j}{\delta}\right) \prod_{y_j = y_j^*} \frac{1}{\delta} \phi \left(\frac{y_j - \beta' X_j}{\delta}\right) \prod_{y_j = L_{2j}} 1 - \varphi\left(\frac{L_{2j} - \beta' X_j}{\delta}\right) \qquad (7)$$

Where: $L_{1j} = 0$ (lower limit) and $L_{2j} = 1$ (upper limit) where $\varphi(.)$and $\phi(.)$are normal and standard density functions. It is better to work with log of likelihood function rather than likelihood since the log function is monotonically increasing function **(Greene, 2003).**

Like traditional regression coefficients, the regression coefficients of the two-limit Tobit regression model cannot be interpreted, that give the extent of the marginal effects of change in the predictor variables on the likely value of the response variable. In a Tobit model, each marginal effect includes both the influence of explanatory variables on the probability of explained variable to fall in the uncensored part of the distribution and on the expected value of the dependent variable conditional on it being larger than the lower bound. Thus, the total marginal effect takes into account that a change in independent variable will have a simultaneous effect on probability of being technically, allocatively and economically efficient and value of technical, allocative and economic efficiency scores. A useful breakdown of marginal effects was extended by **Gould *et al.* (1989).** From the likelihood function of the model stated in equation (7), **Gould *et al.* (1989**) proved the equations of three marginal effects as follows:

a. The unconditional expected value of the dependent variable (Eq. 8).

$$\frac{\partial \text{E(y)}}{\partial \text{x}_\text{j}} = [\varphi(\text{Z}_\text{U}) - \varphi(\text{Z}_\text{L})].\frac{\partial \text{E}(\text{y}^*)}{\partial \text{x}_\text{j}} + \frac{\partial[\varphi(\text{Z}_\text{U} - \varphi(\text{Z}_\text{L})]}{\partial \text{x}_\text{j}} + \frac{\partial(1 - \varphi(\text{Z}_\text{U})}{\partial \text{x}_\text{j}} \qquad (8)$$

b. The expected value of the dependent variable conditional upon being between the limits (Eq. 9).

$$\frac{\partial E(y^*)}{\partial x_j} = \beta_n \cdot \left[1 + \frac{\left\{ Z_L \phi(Z_L) - Z_U \phi(Z_U) \right\}}{\{\{\varphi(Z_U) - \varphi(Z_L)\}\}} \right] - \left[\frac{\{\phi(Z_L) - \phi(Z_U)\}^2}{\{\varphi(Z_U) - \varphi(Z_L)\}^2} \right] \quad (9)$$

c. The probability of being between the limits (Eq. 10).

$$\frac{\partial[(\varphi(Z_U) - \varphi(Z_L)]}{\partial x_j} = \frac{\beta_n}{\sigma} \cdot \left[\phi(Z_L) - \phi(Z_U) \right] \quad (10)$$

Where: $\varphi(.)$the cumulative normal distribution, $\phi(.)$ the normal density function, $Z_L = -\beta' X/\sigma$ and $Z_U = (1 - (\beta X))/\sigma$ are standardized variables that came from the likelihood function given the limits of y^*, and σstandard deviation of the model. The marginal effects represented by the equations above were calculated by the STATA command.

Hypothesis tests that cannot be applied in non-parametric models, are possible in stochastic production frontier model. Different hypothesis tests were made for this study by using the likelihood ratio (LR) test given by Equation (11) following Greene (2003).

$$LR(\lambda) = -2ln[L(H_o)] - ln[L(H_1)] \quad (11)$$

Where:
$L(H_0)$ likelihood function value under (H_0);
$L(H_1)$ likelihood function value under (H_1).

In most cases, this function has an asymptotic chi-square distribution. Thus, if the value of LR (λ) exceeds the critical/tabulated χ^2 statistic, then the null hypothesis would be rejected in favour of the alternative and vice versa. All the parameters of production frontier, dual cost frontier and two limit Tobit model were estimated using STATA.

RESULTS AND DISCUSSION

On average, the sampled households produced 15.08 qt of wheat, which is the regressand variable in the production function. The land allocated for wheat production, by sampled households during the survey period was ranged from 0.125 to 2.5 ha with an average of 0.712 ha. Similarly, on average the sampled farmers incurred 13,607.46 birr to produce 15.08 quintal of wheat. Among the five factors of production, the cost of land and labour accounted the highest share 30.79 and 27.79%, respectively (Table 1).

The review statistics of demographic, socioeconomic, farm and institutional variables which were expected to affect technical, allocative and economic efficiency levels of smallholder farmers in the study area are presented in Table 2 and 3.

Table 1.Summary statistics of variables used to estimate the production and cost function

Variables	Unit	Mean	Std.Dev.	Min	Max
Output	Quintal	15.08	10.8	2	57
Seed	Kilogram	122.75	85.57	20.00	445
Land	Hectare	0.712	0.45	0.125	2.5
Labour	Man-days	62.21	37.4	10.00	215.6
Mineral fertilizers	Kilogram	118.09	82.9	20.00	525
Oxen	Oxen-days	29.43	15.62	5.00	81
Total cost of production	Birr	13,607.46	10,274.58	1,700	59,850
Cost of seed	Birr	9,73.48	900.65	131.25	6500
Cost of land	Birr	4,037.45	2,492.11	678.12	12000
Cost of labour	Birr	3,644.37	2,199.40	650	11858
Cost of mineral fertilizers	Birr	1,240.15	888.17	202.8	6037.5
Cost of oxen	Birr	3,217.05	1,767.18	475	11400

Source: own computation (2018)

Table 2. Summary of continuous variables used in efficiency model

Variables	Sample mean	Std. deviation	Min.	Max.
Age of the household head (years)	47.89	10.05	24	75
Family size (ME)	6.12	1.80	2	11.4
Educational level (years)	5.82	3.04	0	12
Frequency of extension contact	5.69	2.69	0	12
Cultivated land (ha)	0.84	0.70	0.25	3.5
Livestock (TLU)	6.95	3.17	1.68	15.15
Distance to the nearest market (min)	32.97	13.32	3	55
Land fragmentation	2.08	0.85	1	4

Source: own computation (2018)

Table 3. Summary of dummy variables used in efficiency model

Variables	Description	Frequency	Percentage
Sex of the household head	Male (1)	118	77.63
	Female	34	22.37
Fertility status of the soil	Yes (Fertile) (1)	112	73.68
	No (Infertile)	40	26.32
Credit utilization	Used (1)	89	58.55
	Not used	63	41.45
Participation in off/non-farm activities	Yes (1)	103	67.76
	No	49	32.24

Source: own computation (2018)

Hypotheses test

In this study, three hypotheses were tested. Accordingly, the functional form that can best fit to the data at hand was selected by testing the null hypothesis which states that the coefficients of all interaction terms and square specifications in the translog functional forms are equal to zero $(H_0: \beta_{ij} = 0)$ against alternative hypothesis $(H_1: \beta_{ij} \neq 0)$. This test was made based on the value of likelihood ratio (LR) statistics which could be computed from the log likelihood values of both the Cobb-Douglas and Translog functional forms using Equation 12.

$$\lambda = -2[logL(H_0) - logL(H_1)] \quad (12)$$

The λ value computed by the above formula was compared with the upper 5% critical value of the χ^2 at the degree of freedom equals to the difference between the number of independent variables used in both functional forms (in this case degree of freedom =15). Accordingly, the log likelihood functional values of both Cobb-Douglas and Translog production functions were -34.84 and -26.32 respectively. Therefore, the λ value computed was 17.04 and this value is lower than the upper 5% critical value of χ^2 at 15 degrees of freedom (24.9) (Table 4). As a result, the null hypothesis was accepted and the Cobb-Douglas functional form best fits the data.

The second test is to test the null hypothesis that the inefficiency component of the total error term is equal to zero $(\gamma = 0)$ and alternative hypothesis that inefficiency component different from zero. Thus, the likelihood ratio is calculated and compared with the χ^2 value at a degree of freedom equal to the number of restrictions (the inefficiency component) estimated by the full frontier, which is 1 in this case for all models.

As explained in Table 4, one-sided generalized λ test of $\gamma = 0$ provide a statistics of 12.2 for wheat production; which is significantly higher than the critical value of χ^2 for the upper 5% at one degree of freedom (3.84). As a result, the null hypothesis that states wheat producers in the study area are fully efficient is rejected.

The third hypothesis tested was that all coefficients of the inefficiency effect model are simultaneously equal to zero (i.e.$H_0: \delta_0 = \delta_1 = \delta_2 = \cdots \delta_{12} = 0$) against the alternative hypothesis, which states that all parameter coefficients of the inefficiency effect model are not simultaneously equal to zero. It was also tested in the same way by calculating the λ value using the value of the log likelihood function under the stochastic frontier model (without explanatory variables of inefficiency effects, H_0) and the full frontier model (with variables that are supposed to determine efficiency level of each farmer, H_1). Using the formula in Equation (12), the value λ obtained was 77.56, which is higher than the critical χ^2 value (21.03) at the degree of freedom equal to the number of restrictions to be zero (in this case the number of coefficients of the inefficiency effect model was 12). As a result, the null hypothesis is rejected in favour of the alternative hypothesis that explanatory variables associated with inefficiency effect model are simultaneously not equal to zero.

The MLE of the parametric stochastic production frontier

Given the specification of Translog, the Cobb-Douglas stochastic production was tested and found to best fit to the data and was used to estimate efficiency of farmers. The dependent variable of the estimated production function was wheat output (Qt) and the input variables used in the analysis were area under wheat (ha), oxen (pair of oxen-days), labour (man-days in man-equivalent), quantity of seed (kg) and quantity of fertilizer (Kg).

Land allotted for wheat production and mineral fertilizers are found to be statistically significant at 1% significance level implying that increasing the level of these inputs would increase wheat yield in the study area. Mineral fertilizers also appeared to be an important factor, with coefficient of 0.353. This implies that a 1% increase in mineral fertilizers enhance wheat output by about 0.35% at ceterius paribus. This result is in line with the empirical results of **Fekadu and Bezabih (2008), Tolesa *et al*.(2014), Sisay *et al.(*2015), Ahmed *et al.* (2015), Mekonnen *et al*. (2015), Tiruneh and Geta (2016), Beshir (2016), Mustefa *et al.* (2017)** and **Nigusu (2018).**

The coefficients related with the inputs measure the elasticity of output with respect to inputs. The results showed that the input variables specified in the model had elastic effect on the output of wheat production. The scale coefficient calculated was 1.214, indicating increasing returns to scale. This implies that there is potential for wheat producers to expand their production because they are in the stage I production area. This implies that, a 1% increase in all inputs proportionally would increase the total production of wheat by 1.214%. Therefore, an increase in all inputs by 1%would increase wheat output by more than 1%.

Table 4. Generalized Likelihood Ratio test of hypotheses for parameters of SPF

Null hypothesis	Df	λ	Critical value	Decision
$H_o: \beta_{ij} = 0$	15	17.04	24.9	Accept H_0
$H_o: \gamma = 0$	1	12.2	3.84	Reject H_0
$H_o: \delta_0 = \delta_1 = \delta_2 = \cdots \delta_{12} = 0$	12	77.56	21.03	Reject H_0

Table 5. Estimates of the Cobb Douglas frontier production function

Variables	Parameters	MLE Coefficient		Std. Err.
Intercept	β_0	0.561		0.560
Lnseed	β_1	0.179**		0.076
Lnland	β_2	0.481***		0.115
Lnlabor	β_3	-0.091		0.098
Lnfertilizer	β_4	0.353***		0.075
Lnoxen	β_5	0.109		0.094
Variance parameters:				
$\sigma^2 = \sigma_v^2 + \sigma_u^2$			0.166***	
$\lambda = \frac{\sigma_u}{\sigma_v}$			1.451***	
Gamma (γ)			0.678	
Log likelihood			-34.84	

Note: ** and *** refers to 5 and 1% significance level, respectively.
Source: Model output (2018)

This result is consistent with the empirical results of **Beshir (2016)** and **Assefa (2016)** who estimated the returns to scale of 1.33 and 1.38% in the study of technical efficiency of wheat production in South Wollo and Hadiya zone, Ethiopia respectively.

The diagnostic statistics of inefficiency component reveals that sigma squared (σ^2) was statistically significant which indicates goodness of fit, and the correctness of the distributional form assumed for the composite error term. The estimated value of Gamma γ is 0.6778 which indicates that 67.78% of total variation in farm output from the frontier is due to technical inefficiency and the remaining 32.22% was due to factors beyond the control of farmers. The dual frontier cost function derived analytically from the stochastic production frontier shown in Table 5 is given by Eq. 13.

$$lnCi = 3.47 + 0.07lnw_{1i} + 0.26lnw_{2i} + 0.02lnw_{3i} + 0.23lnw_{4i} + 0.02lnw_{5i} + 0.48lnY_i^* \quad (13)$$

Where: C_i is the minimum cost of production of the i^{th} farmer, Y^*refers to the index of output adjusted for any statistical noise and scale effects and wstands for input costs.

Efficiency scores and their distribution

The mean TE of sample farmers was about 0.78. This means that if the average farmer in the sample was to achieve the technical efficient level of its most efficient counterpart, then the average farmer could realize 17.12% derived from (1-0.784/0.946)*100 increase in output by improving technical efficiency with existing inputs and technology. The average AE of the sample farmers was about 0.80. This shows that farmers are not allocatively efficient in producing wheat and hence, a producer with the mean score of allocative efficiency should have outlay saving of about17.19% .Similarly, the mean EE of the sample farmers was 0.63 implying there is low level of economic efficiency in wheat production in the study area. The estimated average efficiency levels of smallholder wheat producers in the study area (Table 6) can be compared to other efficiency studies made in different parts of our country. Consequently, **Nigusu (2018)** found mean TE, AE and EE of 0.79, 0.83 and 0.66 respectively for teff producers in Northern Shewa, Ethiopia. In addition, **Solomon (2012)** found mean TE, AE and EE of 0.79, 0. 47 and 0.37 respectively for wheat seed producer farmers in West Gojjam, Ethiopia.

Table 6: Estimated technical, allocative and economic efficiency scores

Types of efficiency	Mean	Std.Dev.	Min	Max.
TE	0.784	0.090	0.289	0.946
AE	0.809	0.114	0.343	0.977
EE	0.635	0.109	0.099	0.911

Source: Model output (2018)

The distribution of the technical efficiency scores showed that about 47.36% of the sample households had technical efficiency score of between 80 to 90%. The allocative efficiency distribution scores indicated that about27.63% of wheat producers operated above 90% efficiency level. The distribution of economic efficiency scores implies that 36.18% of the household heads have an economic efficiency score of 50-60%. This indicates the existence of low economic efficiency than technical and allocative efficiencies in the production of wheat during the study period in the study area (Figure 2).

Determinants of efficiency

A two limit Tobit model was used to identify factors that affect efficiency levels among the sampled farmers. In this study, the dependent variable is efficiency scores not inefficiency. Thus, the marginal effect should be interpreted as their effect on efficiency and not inefficiency and if one wants to use inefficiency, the sign of the marginal effect, has to be changed.

The finding of the study shows that age affected allocative and economic efficiency of the smallholder farmers in wheat production positively and significantly at 10 and 1% significance level, respectively. This implies that older farmers were more efficient than younger ones. This was probably because older farmers may have better experience in farming. Moreover, farmers at older age may accumulate good control of resources like oxen, farm tools and labour that could boost their efficiency, since in crop production, better availability of farm resources enhances timely application of inputs that increase efficiency of the farmer **(Kitila and Alemu, 2014).**Furthermore, the computed marginal effect of age of the household head showed that, a one year increase in the age of the household head would increase the probability of the farmer being allocative efficient by about 0.13% and the mean value of allocative and economic efficiency by 0.12 and 0.14% with an overall increase in the probability and the level of allocative and economic efficiencies by 0.14 and 0.14%, respectively (Table 8). This result is in line with the findings of **Ali *et al.* (2012), Kitila and Alemu (2014) and Alemu and Haji (2016).**

The coefficient for sex of the household head was significant and positively affected technical and economic efficiencies of farmers at 1% significance level, as it was expected (Table 7). It indicated male headed households operating more efficiently than their female counterparts. This result is in line with the findings of **Tiruneh and Geta (2016) and Meftu (2016).** As expected, educational level of the household head had a positive and significant effect on TE, and AE at 5% and EE of wheat production at 1% level of significance. This is because education can increase their information gaining and adjustment abilities, thereby- increasing their decision making capacity. In line with this study, research done by **Solomon (2012), Ahmed *et al.* (2013), Sisay *et al.* (2015) and Ahmed *et al.* (2015)**explains that the more educated the farmer, the more technically, allocative and economically efficient s/he becomes.

Soil fertility was positively and significantly affected technical and economic efficiencies at 1 and 5% level of significance, respectively (Table 7). This implies that farmers who have allocated fertile land for wheat production were more technically and economically efficient than their counterparts. This result is consistent with the empirical findings of **(Fekadu and Bezabih, 2008; Awol, 2014; Mekonnen *et al.*, 2015; Assefa, 2016).** Frequency of extension contact had significant and positive effect on technical efficiency at 5%, allocative and economic efficiencies at 1% significance level, respectively. This indicates households who receive more extension contacts by extension workers appear to be more efficient than their counterparts. This result is similar with the findings of **Ahmed *et al.* (2013), Kitila and Alemu (2014), Sisay *et al.* (2015) and Nigusu (2018).**

The coefficient of participation in off/non-farm activity was positive and significant for technical and economic efficiency at 1% whereas allocative efficiency at 5% significance level (Table 7). This effect is may be due to the income obtained from such activities could be used for the purchase of agricultural inputs, and it shifts the cash constraint outwards and enables farmers to make timely purchase of those inputs which they cannot provide from on farm income. This result is in line with the empirical findings of **Haji (2008), Solomon (2012) and Kitila and Alemu (2014).** The coefficient of land fragmentation for technical efficiency is negative and statistically significant at 10% significance level as it was expected. The result confirms the expectation, because fragmented land leads to reduce efficiency by creating lack of family labour, wastage of time and other resources that would have been available at the same time. This result is in line with the empirical results of **Assefa (2016) and Mustefa *et al.* (2017).**

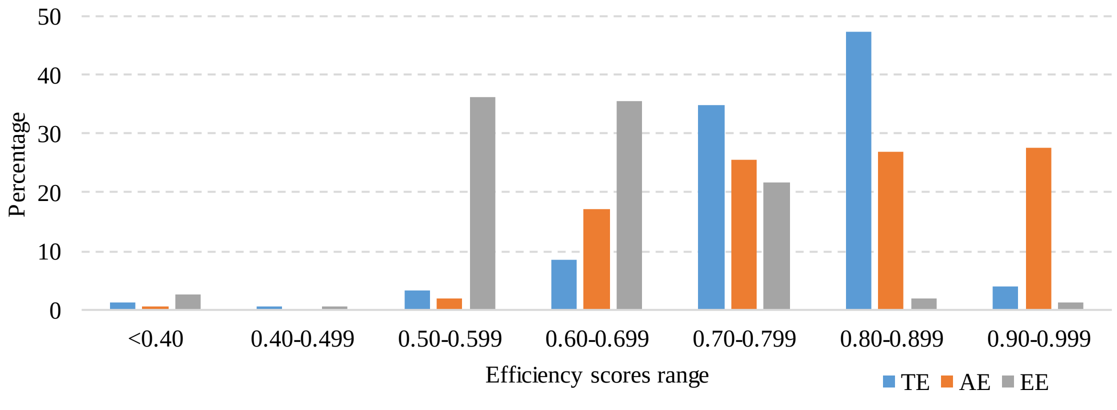

Figure2. Frequency distribution of technical, allocative and economic efficiencies scores
Source: Computed based on model results

Table 7: Tobit regression results of determinants of technical, allocative and economic efficiency

Variable	TE		AE		EE	
	Coefficient	Std.Err	Coefficient	Std.Err	Coefficient	Std.Err
Constant	0.6402***	0.0461	0.5994***	0.0611	0.3656***	0.0423
AGEHH	0.0007	0.0006	0.0015*	0.0008	0.0014***	0.0005
SEXHH	0.0821***	0.0148	-0.0127	0.0196	0.0516***	0.0136
EDUCLHH	0.0048**	0.0022	0.0068**	0.0029	0.0088***	0.0020
FOEC	0.0053**	0.0027	0.0166***	0.0035	0.0171***	0.0024
PONFAC	0.0472***	0.0136	0.0375**	0.0181	0.0648***	0.0125
SOILFERT	0.0375***	0.0137	0.0028	0.0182	0.0252**	0.0126
LANDFR	-0.0135*	0.0070	-0.0008	0.0093	-0.0082	0.0064

Note: *,** and *** refers to level of significance at 10, 5 and 1% respectively.
Source: Model output (2018)

CONCLUSION AND RECOMMENDATIONS

Result of the production function indicated that seed, land and mineral fertilizers were the significant inputs, with positive sign as expected. Among the three significant inputs, mineral fertilizers and land under wheat production had significant and positive influence on wheat production at less than 1% level of significance. This depicts that farmers who allocated more land for wheat production and those who applies more amount of mineral fertilizers receive higher wheat yields. The coefficients related with the inputs measure the elasticity of output with respect to inputs. The results showed that the input variables specified in the model had elastic effect on the output of wheat production. The coefficient calculated was 1.214, indicating increasing returns to scale. This implies that, an increase in all inputs by 1% would increase wheat output by more than 1% in the study area.

The estimated mean values of technical, allocative and economic efficiency levels were 78, 80 and 63%, respectively. This implied that there is an opportunity for wheat producers to increase wheat output at existing levels of inputs and minimize cost without compromising yield with present technologies available in the hands of producers.

Education, extension and participation in off/non-farm activity had positive and significant effect on technical, allocative and economic efficiencies. This shows that more educated farmers, the more farmers have contact with extension agent and farmers participating in off/non-farm activities were more technically, allocatively and economically efficient than their counterparts respectively. In addition, as it was expected sex and soil fertility had positive and significant effect on technical and economic efficiencies, implying that male headed households, household heads who allocate fertile land for wheat production were more technically and economically efficient than their counterparts, respectively. Similarly, age had a positive and significant effect on allocative and economic efficiencies, which implies that older household heads were more efficient than their counterparts. Moreover, land fragmentation had negative and significant impact on technical efficiency.

Based on the results of the study, the following policy recommendations have been drawn. First, using best practices of the efficient farmers as a point of reference would help setting targets in improving efficiency levels and finding the weakness of the present farm practices. The relatively efficient farms can also improve their efficiency more through learning the best resource allocation decision from others. This can be achieved by arranging field days, cross-visits, creating forum for experience sharing with elder households and on job trainings.

Age showed a positive and significant effect on efficiency. Therefore different mechanisms should be devised to encourage farmers with little experience to work with the experienced ones or train them. The results of the study also shows, as female household heads were less efficient than male household heads. Thus, provision of improved technologies that can help female farmers in decreasing their home burden and this would in turn help them to improve their efficiency level in wheat production have to be practiced in the study area.

In the study area, education of household heads had positive and significant effect on technical, allocative and economic efficiencies. Hence, the key policy implication is that appropriate policy should be designed to provide adequate and effective basic educational opportunities for farmers in the study area. Extension contact has positive and significant effect on technical, allocative and economic efficiencies in the study area. Therefore, suitable and sufficient extension services should be provided for wheat producers. The study also found that, participation in off/non-farm activity had a positive and significant effect on technical, allocative and economic efficiencies. Therefore, strategies that enhance the ease use of off/non-farm employment opportunities would help to increase the timely and appropriate use of inputs for better efficiency in wheat production in the study area. Moreover, technical and economic efficiency were positively and significantly affected by soil fertility. Therefore, improvement of the soil status by applying organic manures and practicing different soil conservation techniques should have to done by farmers.

Acknowledgements

Special gratitude goes to farmers who participated in this study and development agents of Abuna Gindeberet District for their cooperation during data collection.

Table 8. The marginal effects of change in explanatory variables

Variables	Marginal effects (TE)			Marginal effects (AE)			Marginal effects (EE)		
	$\frac{\partial E(y)}{\partial x_j}$	$\frac{\partial E(y^*)}{\partial x_j}$	$\partial[(\varphi(Z_U) - \varphi(Z$ / ∂x_j	$\frac{\partial E(y)}{\partial x_j}$	$\frac{\partial E(y^*)}{\partial x_j}$	$\partial[(\varphi(Z_U) - \varphi($ / ∂x_j	$\frac{\partial E(y)}{\partial x_j}$	$\frac{\partial E(y^*)}{\partial x_j}$	$\partial[(\varphi(Z_U) - \varphi(Z_L$ / ∂x_j
AGEHH	0.00069	0.00065	0.00028	0.00143	0.00125	0.00129	0.00145	0.00145	0.00000
SEXHH	0.08161	0.07870	0.02020	-0.01222	-0.01062	-0.01182	0.05157	0.05157	0.00002
EDUCLHH	0.00470	0.00444	0.00193	0.00659	0.00577	0.00593	0.00879	0.00879	0.00000
FOEC	0.00520	0.00491	0.00213	0.01600	0.01401	0.01441	0.01709	0.01709	0.00001
PONFAC	0.04681	0.04459	0.01577	0.03628	0.03215	0.02901	0.06484	0.06483	0.00004
SOILFERT	0.03722	0.03550	0.01194	0.00271	0.00237	0.00241	0.02524	0.02524	0.00001
LANDFR	-0.01333	-0.01257	-0.00546	-0.00078	-0.00069	-0.00071	-0.00817	-0.00816	-0.00000

Note: Marginal effects are computed only for significant variables and values under column $\frac{\partial E(y)}{\partial x_j}$ shows (Total change), $\frac{\partial E(y^*)}{\partial x_j}$ shows (Expected change) and $\frac{\partial[(\varphi(Z_U)-\varphi(Z_L)]}{\partial x_j}$ shows (change in probability).

Source: Model result

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REGULAR ARTICLE

POLICY FOR IMPROVING ADOPTION AND PROFITABILITY OF IRRIGATION IN BENIN

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ABSTRACT

Majority of the irrigation schemes developed in Benin failed upon the withdrawal of foreign partners in 1980s, and these schemes were abandoned by farmers. The 2008 food crisis and the new challenge of climate change and variability have renewed Benin government interest to invest in irrigation development to achieve food security. This article explores the policies needed for such investments to be successful and improve adoption of irrigation and farmers' profitability using a case study from the rice irrigation scheme of Malanville, Benin. Results indicate that irrigated rice farming is profitable in Benin. Furthermore, profitability is positively correlated with education, access to credit, extension services, soil quality, amount of fertilizer and herbicide applied, and ownership of mobile phone. Policy reforms needed to sustain the development of irrigation and to increase profits include the development of irrigation policy document, the reinforcement of institutional supports for farmers, and the improvement in the production practices.

Keywords: Adoption, Irrigation, Policy, Rice, Benin
JEL: L25, Q15, Q18

INTRODUCTION

Rainfall in Benin is characterized by large spatial and temporal variations making the production of rainfed crops very uncertain. The average rainfall in Benin is between 700 mm and 1500 mm per year (**Attogouinon *et al.*, 2017**). In addition to this relative good rainfall condition, the country has significant hydro-agricultural resources consisting of several water flows and valleys. The country has four (4) major hydrographic units, namely: the hydrographic units of Niger, Volta, Ouémé, and Mono. These increase the potential of irrigation in Benin. The government of Benin believes that irrigation development may contribute to improve domestic food production especially rice output. This belief led to the development of irrigation schemes throughout the country since 1960 with objective to reduce food insecurity and poverty.

Despite an increase in the total land developed for irrigated crop production from 3,932 ha in 1975 to 23,040 ha in 2008 (**FAO, 2014)** less than 10% of the irrigation potential in Benin is developed and the irrigation facilities are sub-optimally used. About 25% of the total area developed for irrigation purpose in Benin were unused **(FAO, 2014).** In the irrigation scheme of Malanville (study area) in 2015, of the 516 ha of irrigable land, 116 ha were uncropped. Similar situation is observed on the other irrigation schemes in Benin. As an example, of the 88 ha of land in the irrigation scheme of Zonmon, 51.9 ha were unused. In the irrigation scheme of Bamè, of the 33 ha of irrigable land, 20.5 ha were uncropped. Better situation seems to be observed in the irrigation scheme of Koussin-lélé where of the 120 ha of land, only 8.2 ha were unused.

Majority of the irrigation schemes developed in Benin have failed upon the withdrawal of foreign partners in 1980s. This was due notably to the lack of producers' involvement in the management process and the lack of technical expertise required for the development of irrigation practices **(MAEP, 2009a).** With regard to this, the main research question is, what policy can facilitate farmers' adoption of irrigation and improve profitability without repeating the past and current failures? The present study aims to provide policy for improving farmers' adoption of irrigation and profitability in Benin. The specific objectives are: (1) to estimate the profitability of irrigated rice production, (2) to assess factors that influence the profitability of irrigated rice production, and (3) to discuss policy needed to improve profitability of irrigated rice production.

This study complements previous studies in Benin by **Totin *et al.* (2012)** and **Djagba *et al.* (2014)** but is more focused on the policy issues for increasing participation to irrigation and profitability in the country. The analysis in this study is based on the survey of 150 irrigated rice farmers from the irrigation scheme of Malanville in 2015. A total of 1054 farmers were operating on the scheme and were classified in 24 groups comprising between 20 and 100 farmers. Therefore, a proportional sampling technique was used to obtain the random sample.

The rest of the paper is arranged as follows. The next section presents the history and context of irrigation development in Benin, followed by section which analyse the profitability of irrigated rice production. The following section deals with the policy option for improving use of irrigation and profitability. Final section provides the conclusion.

IRRIGATION DEVELOPMENT IN BENIN

Irrigation potential and practices in Benin

Irrigation development in Benin is at an early stage with only a small number of smallholder farmers cultivating crops under irrigation. The irrigated crops in Benin are rice, sugar cane, vegetables, roots and tubers **(MAEP, 2009a).** The total irrigation potential is estimated at 322,000 ha, of which 205,900 ha is lowland and 117,000 ha account for upland that could be irrigated in the hydrographic units of Ouémé, Mono and Niger. The irrigation scheme began with small gardeners concentrated around major urban centers and large cities which produced essentially vegetables or fruits on the very small areas of a few tens or hundreds square meters. The first remarkable actions in the area dates back to the 1960s with the establishment of some irrigation schemes for various crops. These schemes have been the result of several public collaborations including the state and some of the international institute such as the World Bank (WB), the Food and Agriculture Organization (FAO), the West African Rice Development Association (WARDA), the African Development Bank (AFDB) and the Chinese technical partners.

Several irrigation systems (gravity, pump, manual watering, etc.) are used according to the financial capacity of the producers. Surface irrigation is practiced on 46 % of the total area, followed by sprinkler irrigation on 42 % of the total area and drip irrigation covers 12 % of the total area under irrigation **(FAO, 2005).** Canal irrigation is used in all irrigated rice schemes in Benin whereas sprinkler irrigation and drip irrigation are mostly used for vegetable production.

Management of irrigation schemes in Benin

Several irrigation schemes were developed between 1970 and 1980. A total of 4,500 ha of lowland, valleys and streams were arranged to develop rice cultivation, vegetables, fruit crops and industrial crops (oil palm and sugar cane). The irrigation schemes were public initiatives under the control of the State with technical and financial support from the international partners. The state manages these schemes through its companies such as the Société Nationale d'Irrigation et d'Aménagement Hydro-agricole (SONIAH), the Société Béninoise de Palmier à Huile (SOBEPALH), the Société Sucrière de Savè (SSS), the Société Nationale des Fruits et Légumes (SONAFEL) which were in charge of the irrigation schemes of rice, oil palm, sugar cane and vegetables and fruits, respectively. These companies used salaried labour and occasionally hired casual labour for all agricultural operations. Very early, in its management, this operating system began to show its limits and most of the schemes have been unsubscribed. The main reason was the lack of producers' involvement in the management of these facilities **(MAEP, 2009a).**

Between 1980 and 1990, the schemes management status changed and the schemes were placed under the responsibility of the Regional Center for Rural Development (CARDER). Farmers who previously were working for the state companies, are now working on their own, but they have to respect the regulations under the schemes. These regulations include the respect of the environment, the payment of water fees and for other inputs and services. Again, this management system failed to meet expectation. The reason was that the farmers did not have the technical expertise required for the development of the irrigation practices **(MAEP, 2009a).** Hence they abandoned the production under irrigation. From the major irrigation schemes developed in the 1970s, there remains today only a few schemes, namely, the Sugar Cane Scheme of Savè and the Rice Schemes of Malanville, Koussin-lélé and Dévé **(MAEP, 2009a).** Since 1990, the limited results of the irrigation schemes has led the government of Benin to choose as priority the following actions for the future: (a) the promotion of small scale irrigation facilities, (b) the rehabilitation of some of these old irrigation schemes and, (c) the involvement of beneficiaries in the management process of these schemes.

On the rice irrigation scheme of Malanville, which is the biggest rice scheme in Benin, there were approximately 1054 rice farmers in 2015 classified in groups of 20 to 100 people with a total of 24 groups. Each group is led by a committee of three (3) people, and a broad committee of thirteen (13) members is in charge of managing the scheme. The committee's role is to ensure the provision of water, other inputs and services from production to the marketing of rice. At the end of each season, the producers pay back a fee of three bags of 84 kg of rice per plot of 0.25 ha to the committee. The committee is supposed to use a part of the fees collected to ensure the maintenance and rehabilitation of the irrigation system. But in reality, since 1990, the rehabilitation of the irrigation scheme has been the responsibility of the State that intervenes every 10 or 15 years to rehabilitate the scheme.

DATA AND METHODS

Data and sampling procedure

Data used in this study was collected in 2015 from the irrigation scheme of Malanville in Benin. The irrigation scheme of Malanville is the most important in the country in terms of size and yield. The total irrigable land under the scheme is 516 ha of which 400 ha were used in 2015. The scheme was constructed in 1970. The water used is pumped from the Niger River and distributed into the farms through surface canals. Mono-cropping is practiced with rice produced by approximately 1054 farmers operating on the scheme in 2015. In its management, the scheme is designed to serve the five districts in the municipality of Malanville. The State is the owner of the irrigated land and irrigated land size ranges from 0.25 ha to 2 ha. The average rice yield is about 5.7 Mt/ha.

Cochran's (1977) formula (Eq.1) was used to determine the sample size required for the sample to be statistically representative of the irrigation farmers' population.

$$n = z^2 * p(1-p)/m^2 \quad (1)$$

Where: n is the required sample size; z is the confidence level at 95% (standard value is 1.96); p is the estimated prevalence of rice farmers using irrigation; and m is the margin of error at 5%. Using the above formula, a sample size of 126 is obtained. However, for oversampling 150 irrigation farmers were finally selected for the survey. To select these farmers we used a proportional sampling technique based on a list provided by the committee in charge of the management of the irrigation scheme. This sampling technique helps to ensure a fair representation of farmers as they are in groups of 20 to 100 people with a total of 24 groups operating on the scheme in 2015. Information collected concern socio-economic and demographic characteristics of farmers and production (inputs, output, prices, etc…).

Analytical Framework of Profitability of Irrigated Rice Production

The estimation of profit derived from the irrigated rice production was estimated using a farm budget analysis as expressed by the Eq. 2.

$$GM = TR - \sum_{i=1}^{n} OP \qquad (2)$$

Where: *GM* is the gross margin per hectare (ha), *TR* the total revenue per ha calculated as the product of the total quantity of rice output (in number of bags) and the price of a bag. *OP* is the operating costs including the costs of seeds, labour, fertilizer, herbicide, equipment (hoe, cutlass among others), and irrigation water fees.

Multiple regression analysis was done to determine factors that influence profitability of irrigated rice production. The farm profit is considered as a linear function of the socio-economic and demographic characteristics of the farmers as well as institutional variables. The estimated regression model is presented as follows:

$$Y_i = \beta X_i + \mu_i \qquad (3)$$

Where: Y_i represents profit, β is a vector of parameters to be estimated, μ the error term. X_i is the vector of explanatory variables including age, gender, education, access to credit, extension services, membership of farmers based organization (FBO), engagement in off farm activities, perceived soil quality, quantity of fertilizer applied, quantity of herbicide applied, quantity of seed applied, ownership of mobile phone and access to media. Table 1 presents definition, measurement and expected signs of the variables used in the regression model.

RESULTS AND DISCUSSION

Profitability of irrigated rice production

The results are presented in Table 2. The average total revenue per hectare for irrigated rice production was estimated at CFA 904,577 while the total production cost per ha was CFA 416,285. This clearly shows a positive gross margin estimated at CFA 488, 292 per ha. With regard to high profitability from irrigated rice production, the importance given to investment in irrigation development in Benin was justified.

Table 1: Definition and measurement of explanatory variables and expected signs

Variables	Measurement	Expected signs
Age	Number of years	+/-
Gender	Binary (1= male, 0 = female)	+/-
Education	Binary (1 if educated, 0 = otherwise)	+
Access to credit	Binary (1= Yes, 0 = No)	+
Extension services	Binary (1=Yes, 0 = No)	+
FBO membership	Binary (1=Yes, 0 = No)	+
Off farm activities	Binary (1=Yes, 0 = No)	+
Soil quality	Binary (1=fertile, 0 = otherwise)	+
Quantity of fertilizer applied	Kg/ha	+
Quantity of herbicide applied	Kg/ha	+
Quantity of seed applied	Kg/ha	+
Ownership of mobile phone	Binary (1=Yes, 0 = No)	+
Access to media	Binary (1= if farmer has radio or TV, 0 = otherwise)	+

Table 2: Profitability of rice production on the irrigation scheme of Malanville

Items cost per hectare	Irrigation farming
Seed	12, 990
Labour	110, 078
Fertilizer	61, 360
Herbicide	12, 834
Agricultural equipment	50, 469
Irrigation water fees	168, 000
Transaction cost	554
Total cost per hectare	416, 285
Total revenue per hectare	904, 577
Gross Margin per hectare	488, 292

Note: All items are in CFA franc which is Benin currency. At the time of survey USD 1= CFA 591.25

The disaggregation analysis of the profit across some socio-economics and institutional characteristics of the farmers revealed significant differences (Table 3). It is observed that female farmers have higher profit per ha compared to male farmers. Educated farmers have higher farm profit than the non-educated farmers. This is in line with the idea that education improves farmers' ability to change farming practices and to adopt a new technology to enhance farm production **(Duraisamy, 2002; Adeoti, 2009; Nonvide, 2017).** Farmers that were engaged in off farm activity have higher profit than those who did not. Involvement in off farm activity is an additional source of income for the farmers. The off farm income may be reinvested to increase farm production **(Nonvide, 2017)** and thus to improve profitability. Institutional factors associated with increased farm profitability include extension services and credit. Farmers that had access to extension services have significantly higher profit compared to those who did not. This suggests that regular contact with extension agents contributes to increase farm profit. The extension agents can provide support to farmers in term of agronomic practices and new technologies aimed to increase farm productivity. They can also help in linking farmers to market (both inputs and output markets). It is also observed significant difference in profit between farmers that had received credit and those who did not. This suggests that access to credit is likely to increase farmer's profit from rice production. It enables farmers to purchase farm inputs in time **(Mdemu *et al.*, 2017).**

Table 3: Difference in profit across farmers' characteristics

Variables	Profit	t-test
Gender		
Male	462, 430	
Female	596, 205	
Difference	133, 776	2.39**
Marital status		
Married	480, 544	
unmarried	520, 622	
Difference	40, 078	0.70
Education		
Non educated	336, 718	
Educated	715, 655	
Difference	-378, 937	-11.22***
Extension services		
Yes	283, 267	
No	501, 380	
Difference	-218, 113	-2.34**
Access to credit		
Yes	536, 935	
No	315, 834	
Difference	-221, 101	-4.31***
Off farm activities		
Yes	529, 333	
No	406, 212	
Difference	-123, 121	-2.63***

Note: *** $p < 0.01$; ** $p < 0.05$

The results of the regression model are reported in Table 4. The model has a good fit with its explanatory variables as indicated by the significance of the F-statistic. The results show that the explanatory variables together explain 72% of the total variation in the profitability of irrigated rice production. Variables such as education, access to credit, extension services, soil quality, quantity of fertilizer and herbicide applied, and ownership of mobile phone were found to be significant determinants of the profitability of irrigated rice production.

The coefficient of the education dummy is significant and positively correlated with irrigated rice profitability. This implies that educated farmers have higher profit compared to non-educated. In regard to the literature this could be explained by the fact educated farers have more ability to access information which could enable them in making better farm management decision **(Adeoti, 2009; Dang, 2017).** We also found that access to credit has a positive and significant effect on profit, implying that farmers that have access to credit have higher credit compared to those who did not. This result is in line with **Hyuha *et al.* (2007).** With credit farmers could purchase fertilizers, herbicides and other inputs which could support production, improve crop revenue and profitability. Access to extension services has a positive effect on irrigated rice profitability. This suggests that farmers that have contact with extension agents were found to have higher profit than those who did not. Access to extension services is key to improve farmers' knowledge on agronomic practices which could enable them to increase production. This result agrees with previous findings by **Haq (2012)** in Bangladesh and **Antwi and Aborisade (2017)** in Ghana who found rice farmers' access to extension services reduces yield losses and improves profitability.

Table 4: Determinants of profitability of irrigated rice production

Dependent variable: Ln profit	Coefficient	Robust std. error	P-value
Age (in years)	0.008	0.006	0.181
Gender (male =1)	0.041	0.130	0.751
Education (educated =1)	0.168*	0.097	0.088
Access to credit (yes =1)	0.998***	0.189	0.000
Extension services (yes =1)	0.841*	0.460	0.070
FBO membership (yes =1)	-0.349	0.567	0.539
Off farm activities (yes =1)	0.099	0.102	0.332
Soil quality (fertile =1)	0.280***	0.105	0.008
Quantity of fertilizer applied (kg/ha)	0.002*	0.001	0.075
Quantity of herbicide applied (L/ha)	0.087**	0.041	0.039
Quantity of seed applied (kg/ha)	-0.005	0.003	0.121
Ownership of mobile phone (yes = 1)	0.265***	0.085	0.002
Access to media (1 if radio or TV)	0.130	0.177	0.464
Constance	1.261*	0.731	0.087
$R^2 = 0.72$; $F(13, 136) = 17.42$; Prob > F = 0.0000			

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

The quality of the soil is also an important determinant of profitability. This variable has a positive and significant effect on irrigated rice profitability, implying that farmers that perceived their soil as fertile have higher profit compared to the other. As expected the amount of fertilizer and herbicide applied has positive and significant effect on rice profitability. This implies that rice profitability increases with increase in inputs application. Our results suggest that farm production intensification is key for improving profitability. Finally, we found that ownership of mobile phone is important determinant of rice profitability. Farmers that own mobile phone have higher profit compared to those who did not. This suggests that agricultural information could be shared trough mobile phone. **Mittal and Tripathi (2009)** argue that mobile phone could be a catalyst to improving agricultural productivity and income if the shared information has the following characteristics: quality, timeliness and trustworthiness.

Discussion

Over four decades, government, private sector enterprises, technical and financial partners have invested in the development of irrigation with the purpose to intensify food crop production and improve returns to rural farmers in Benin. This study has shown that profitability of irrigated rice production depends on farmers' socio-economic characteristics, institutional variables and farm production factors such as education, access to credit, extension services, soil quality, quantity of fertilizer and herbicide applied, and ownership of mobile phone. These variables must be considered in designing policy for the development of irrigation in Benin. In the following, three categories of policies to improving farmers' adoption of irrigation and profitability are discussed: irrigation policy; institutional support measures; and production policy.

Irrigation Policy

Due to the lack of producers' involvement in the management of the scheme and the lack of technical expertise required for the sustainable development of the irrigation scheme, farmers abandoned the production of rice under irrigation, and most of the scheme have been unsubscribed after the withdrawal of the Chinese and Taiwanese technical partnership. To benefit from the important investment in irrigation without repeating the past actions, and achieve sustainable development of small scale irrigation, it is important to reduce external investments as much as possible and increase farmers' capacity to manage the scheme **(Sakaki and Koga, 2013; Bjornlund *et al.*, 2017).**

Farmers on the irrigation scheme of Malanville reported that the water fees are high, and this is the main factor handicapping the use of irrigation. This situation may be due to the fact that there was no metric of measuring the amount of water used by each farmer. The water fees paid depends on the size of their land. This provides no incentive for water conservation **(Mwamakamba *et al.*, 2017).** The water fees represent about 18% of the total output per hectare. Thus, efforts should be made to reduce these fees for the farmers. Also there is a need to find a way to measure the amount of water used by a farmer in order to set water price equivalent to the real amount of water used. This may contribute to the efficiency use of the water regarding the new challenge of climate change and variability and may benefit others water users.

Although the Strategic Plan to Revitalize Agricultural Sector (PSRSA) in Benin and the rice policy contain some guideline for developing irrigation in Benin, the country does not have any policy document for irrigation development. Therefore, it is important, for sustainable development of irrigation sector in the country, to develop a policy document for irrigation. This document should clearly provide the vision of the country for the development of irrigation and state the strategies that will help in the achievement of the vision. As shown by **Totin *et al.* (2012)** an unclear division of responsibilities between local farmer groups and the government for canal maintenance and a lack of effective local rules for the distribution and maintenance of irrigation infrastructure are factors affecting the successful development of irrigation in Benin. The irrigation policy document should also propose the necessary incentives that may facilitate the adoption of irrigation as many of the irrigation schemes in Benin are sub-optimally used.

Reinforcing institutional support for farmers

The findings reveal that profitability of irrigated rice production depends on institutional factors such as education, extension services and access to credit. Therefore, institutional support should be enhanced. Farmers could be educated through regular training on agronomic practices and other information needed to improve rice production and profitability. Farmers need strong assistance from the extension agents. Regular contact with extension agents may help them to have information on new technology, availability of farm inputs and market information. Extension services is a channel of transferring the skills and knowledge needed for increasing productivity and profitability **(Wheeler *et al.*, 2017).** There are no adequate credit systems and the few rural banks in place are not willing or not able to provide sufficient loan for the farmers. Most of the rice farmers were obliged to turn to local traders in order to get loans despite the high interest rate. As reported by the farmers they paid back sometimes an interest rate of 100 %. Therefore, there is a need to provide credit facilities for the farmers. **Mdemu *et al.* (2017)** argued that lack of credit is the central cause of majority of the constraints faced by smallholder farmers. Lack of credit prevents farmers from timely access to farm technologies resulting in delaying in farm operations **(Bjornlund and Pittock, 2017).**

Farmers in the irrigation scheme of Malanville sell mostly their rice at the farm gate to the State which is the major buyer of rice in the municipality of Malanville. The state buys the rice from the farmers and paid them back later. As most of the farmers are in need of cash, that situation does not provide incentives for them. Also, in the year where the state fails or delays in buying the rice, the situation becomes critical for the farmers. Farmers who were able to sell their rice in the urban markets or to the exporters from the neighbouring countries (Niger, Nigeria and Togo) had higher return despite increased transaction costs. Farmers need information on the price of rice and on the existing market for rice sale. This would enable them to make more informed decision. A good communication mechanism should be put in place to improve information sharing. In this regard, government or agricultural development institutions could help making these information available to farmers. This may be done through radio, television, or mobile phone application since 75% of farmers have radio or television and 73% own mobile phone.

Production practices

The rice yield from the irrigation scheme of Malanville (5.7 metric tonnes per ha) is still below the potential yield (8- 10 metric tonnes per ha) that can be achieved in Benin **(MAEP, 2009b).** This is due to the low use of inputs. While the development of irrigation scheme is often accompanied with provision of farm inputs (seed, fertilizer, herbicide, among others), many farmers tend to use lower than recommended rate. For instance, only 46 %, and 39 % of the surveyed farmers had observed the recommended rate for fertilizer and herbicide application respectively. Discussions with farmers suggest that this is due to the high cost of obtaining inputs. Although the management committee of the scheme provide farmers with the necessary inputs, the farmers reported that due to lack of finance, they made in kind payment for the inputs. For instance, a farmer who received 50kg of fertilizer may paid back at the end of the season 50kg of paddy rice. This is often costly for farmers. Inputs policy reforms are needed to promote easy access to production inputs and increase the use level of inputs in order to optimize productivity and profits. A set of institutional support measures should reinforce the link among credit, inputs and output. Extension agents should play an important role in training farmers on the right usage and benefit of applying recommended rate of inputs.

About 11% of farmers used tractor. This low level of tractor use may be due to the small land allocated to irrigation farmers discouraging investment in mechanization to increase productivity and profits. It is therefore essential to expand irrigated land and facilitate access to mechanization. Other important aspect of the production is the crop choice. This is essential for the viability of small-scale irrigation schemes **(Bjornlund *et al.*, 2017).** Since the establishment of the irrigation schemes of Malanville in 1970, rice is the only crop grown on the scheme. This may lead to poor soil quality and thus to decreasing crop yield. Therefore, there is a need for crop rotation policy to improve crop yield. Crop rotation is essential in sustainable agricultural system as it plays a crucial role in farming by keeping pests and diseases under control, and provides enough nutrients to different crops, and maintain soil quality **(Nel and Loubser, 2004; Filizadeh *et al.*, 2007).**

CONCLUSION

The expectation of the development of irrigation in Benin is to enhance food security and reduce poverty. However, past investments in irrigation development were unsuccessful. This study provides policy to support governments' actions to sustain small scale irrigation schemes in Benin. Case study from the irrigation scheme of Malanville is used to estimate profitability of irrigated rice production and to detail policy needed to improve adoption and profitability of irrigation in Benin. Results reveal that irrigated rice production is profitable in Benin, and depend on variables such as education, access to credit, extension services, soil quality, quantity of fertilizer and herbicide applied, and ownership of mobile phone. Three categories of policies identified to sustain the development of irrigation schemes in Benin are the irrigation policy, the reinforcement of institutional supports for farmers, and the production practices.

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REGULAR ARTICLE

MARKET OUTLET CHOICE DECISION AND ITS EFFECT ON INCOME AND PRODUCTIVITY OF SMALLHOLDER VEGETABLE PRODUCERS IN LAKE TANA BASIN, ETHIOPIA

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ABSTRACT

One of the challenges of perishable vegetable production is selecting appropriate market outlets to deliver the produce fresh and earn better price. Various factors affect producers' decision to choose among the alternative market outlets. This study was aimed to identify determinants of smallholder vegetable producers' decision on market outlet choice and verify the existence of difference in productivity and income of households among different market outlets in Lake Tana basin, Ethiopia. Using primary data collected from a survey of 385 farmers in three districts located in Lake Tana basin, the study estimated multivariate probit model to explain the factors that influence market outlet choice of smallholder vegetable producers. F-statistics was sued to verify the effect of market outlets on productivity and income. The results show that those households choosing both farm gate and local market simultaneously are found at better level of productivity and income. Multivariate probit results show that buyers visit and age of household head simultaneously determined all market outlets decision of producers. Those households visited by buyers at farm or village were found more likely to choose farm gate and roadside market outlets and less likely to sell the produce at market place. The implication is that as far as smallholder producers had access to alternative market outlets, they would earn better income by choosing appropriate combination of market outlets. Interventions that improve access to all market outlets could improve income and boost production of vegetables.

Keywords: Lake Tana basin, Market outlet, Multivariate probit, Smallholder farmers, Vegetable
JEL: D81, Q12, Q13

INTRODUCTION

Vegetable crops are important sources of vitamins, minerals and proteins especially for Ethiopians where malnutrition is a problem because of heavy consumption of cereals such as *teff*, maize and wheat. Ethiopia has favorable agro-climatic conditions for the production of a number of vegetable crops. However, production and consumption of vegetables in the country is very low. For example, **Tsegaye, Ahmed and Dilnesaw (2009)** indicated that vegetable and fruit consumption is very low in Ethiopia and the country can be considered as Vitamin A Deficiency endemic. Production of vegetables relative to national crop production is also very low. In 2015/16 main (*Meher)* production season, vegetable crops took up about 1.44 percent of the area under all crops at national level, and the production estimate of the same crop is about 2.18 percent of the total national peasant crop production of the season (**CSA, 2016**). Smallholder farmers contribute 95% of the fresh vegetable supplies to the domestic urban and regional export markets (**EHDA, 2011**). One of the causes for low production of vegetables is that most small scale vegetable growers are constrained with marketing problems such as low bargaining power due to lack of alternative market outlets, low price for the produce specially during harvesting season, poor infrastructure, poor product handling and storage facilities, and lack of market information (**Bezabih and Hadera, 2007; Moti, 2007; Nigatu *et al.*, 2010**). Though the study area, Lake Tana basin is one of the most potential vegetable production areas in Ethiopia (**EHDA, 2011**), the remoteness of the area from the central market, Addis Ababa, and the existing poor road and communication infrastructure may exacerbate smallholders' vegetable marketing problems. Selecting the existing appropriate market outlets is also a challenge because of various factors that affect producers to select such relevant outlets. A number of studies on choice of market outlets have been carried out in the country. **Bezabih *et al*. (2015)**, **Abebe, Bihon and Gebremedhin (2011)** and **Moti (2007)** revealed that institutional, socio-economic and technical factors influence market outlet choice decisions by farmers. However, no literature have found in the country that attempted to verify the effect of market outlet choice on either productivity or income of producer households. In addition, only few of the literature assume that market outlet choices are interdependent and require a model which can account correlation among market outlets like multivariate probit model. Hence, the study was aimed to verify the effect of market outlet choices on productivity and income of farmers. In addition, the study intended to identify the determinants of smallholder vegetable producers' decision to choose market outlets in Lake Tana basin. It informs concerned actors on specific interventions needed to maximize benefit from vegetable production.

DATA AND METHODS

Description of the study area

This study is conducted in three districts namely Takusa, Libo Kemkem and South Achefer where most parts of their areas lie in Lake Tana basin, Ethiopia. The geographical location of the Lake Tana basin extends from 10.95^0 N to 12.78^0 N latitudes and from 36.98^0E to 38.25^0 E longitudes. It is found in North-west part of Ethiopia, Blue Nile Basin. The majority of the populations are dependent on rain-fed agriculture. The majority of the land area, 51.3% of the Lake Tana Basin is used for agriculture, 29% is agro pastoral area, and 20% of the basin is covered by the lake water (**Setegn, Srinivasan and Dargahi, 2008**). The major crops produced in the basin are *teff*, wheat, millet, maize, chickpea, and barley while the common cash crops are onion, tomato, garlic, pepper and potato.

Data sources and sampling procedure

Combinations of quantitative and qualitative data from both secondary and primary sources were used for this study. Multi-stage sampling techniques were employed to select respondents from vegetable producing farmers. At the first stage, among fourteen districts located in the basin, three districts namely Takusa, Libo Kemkem and South Achefer were selected randomly to undertake formal survey on vegetable farming households. At the second stage, four peasant administrations (PAs) reside in the basin from each of the three districts were selected randomly. Lastly, depending on the number of vegetable producing households in selected PAs, about 385 vegetable producing households were randomly drawn (Table 1). Sample size for producer farmers was determined following **Cochran (1963)** assuming a large population and maximum variability in the proportion of the attributes, and with a desired 95% confidence level and ±5% precision, the resulting sample size

$$N = \frac{Z^2pq}{e^2} = \frac{(1.96)^2(.5)(.5)}{(.05)^2} = 385 \qquad (1)$$

Where: N is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area α at the tails (1-α equals the desired confidence level, 95%), e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and p is 1-p.

Methods of data analysis

Descriptive statistics specifically F-statistics and econometric analysis were used to analyze the effect of market outlet choice on productivity and income, and the determinants of market outlet choice. Productivity was addressed by dividing weighted output of six vegetable crops namely onion, tomato, garlic, potato, cabbage and pepper by total land allocated for these vegetables. The weighted average of the vegetable crops produced on the i^{th} farm, Y_i is defined by (**Sharma *et al*, 1999**).

$$Y_i = \frac{\sum_{r=1}^{S} P_{ri}Q_{ri}}{\sum_{i=1}^{n}(\overline{P_i}/n)} \qquad (2)$$

Where: S denotes the number of different types of vegetable crops, P_{ri} denotes the price received per kg by the i^{th} farm for vegetable crop type r, Q_{ri} denotes the quantity of vegetable crop type r in kg for the i^{th} farm,

$\bar{P} = \sum P_{ri} * \frac{Q_{ri}}{Q_i}$; $Q_i = \sum Q_{ri}$

and n denotes the number of farms in the sample

Gross income was calculated by taking the quantity of vegetables sold to the market, and transport cost was deducted from it to obtain net income collected from vegetable crop sales.

Decision on marketing outlet selection is a discrete choice from among alternative outlets available to producers. Because only the farmer's choice on a particular market outlet type is observed, the following latent structure univariate probit model for choice of each market outlet type can be specified (**Maddala, 1983; Long, 1997; Greene, 2012**).

$$y_i^* = \boldsymbol{X\beta} + u_i$$
$$y_i = \{1\ if\ y_i^* = \boldsymbol{X\beta} + u_i > 0;\ 0\ if\ y_i^* \le 0 \qquad (3)$$

Where: y_i* is the binary latent variable for outlet choice (observed if y_i*>0, 0 otherwise); and $\boldsymbol{X}$ is a vector of household-specific, institutional and socioeconomic factors determining market outlet choice. However, producers might select one or more market outlets simultaneously depending on the expected benefits and risks associated with each market outlets. The potential for simultaneous correlation across different market outlets suggests that a model addressing correlated choices is appropriate. In the presence of correlation among unobserved factors across choices, the simple probit or logit model will produce biased estimates of choice probabilities as well as incorrect standard error for β_j and inferences based on those for determining critical factors determining choices will lead to inconsistent results (**Greene, 2008**). Multivariate probit modeling techniques are appropriate for correcting such biases generated from correlation across choices (**Train, 2003; Greene, 2008**) because they allow for possible simultaneous correlation across alternative choices. Hence, this study adopted multivariate probit econometric technique to simultaneously model the influence of the set of independent variables on each of the different marketing outlet choice decisions, while allowing the unobserved (error terms) to be freely correlated (**Mokhtarian and Tang, 2011; Arinloye *et al*., 2012, 2015).**

Multivariate probit estimates M-equation probit models, by the method of maximum simulated likelihood (**Cappellari and Jenkins, 2003).** The variance-covariance matrix of the cross-equation error terms has values of 1 on the leading diagonal, and the off-diagonal elements are correlations to be estimated ($\rho_{jk} = \rho_{kj}$), and ρ_{jk} = 1 for j = k, for all j, k = 1,…,M). In this study, the marketing outlet decision is considered as a system of a multiple choice equation respective to each type of marketing channel (Eq. 4).

$$Farmgate_i^* = \boldsymbol{X'_1\beta_1} + \varepsilon_{1i}$$
$$Roadside_i^* = \boldsymbol{X'_2\beta_2} + \varepsilon_{2i} \quad (4)$$
$$Marektplace_i^* = \boldsymbol{X'_3\beta_3} + \varepsilon_{3i}$$

Where, E(ε**X**)=0, Var(ε**X**)=1, Cov(ε**X**)=ρ and farmgate$_i$, roadside$_i$ and marketplace$_i$ are binary variables taking the value 1 when farmer i selects farm gate, roadside and market place, respectively and 0 otherwise; $\mathbf{X_1}$ to $\mathbf{X_3}$ are vectors of explanatory variables determining the respective outlet choice variables; β's are vectors of simulated maximum likelihood (SML) parameters to be estimated; ε_1 to ε_3 are correlated error terms in a seemingly unrelated multivariate probit model; and ρ's are tetrachoric correlations between endogenous variables. Possible explanatory variables and associated hypothesis are presented in Table 2.

Table 1: Sample distribution in districts, PAs and households

Districts	Peasant administrations	No of vegetable producer households	Sample proportion	Sample size
Takusa	Chankie	1016	8.4	32
	Mekonta	636	5.2	20
	Achera	1085	8.9	34
	Chemera	942	7.8	30
	District Total	3679	30	116
Libo Kemekem	Angot	1110	9	35
	Shina	1098	9	35
	Shamo	1033	8.5	33
	Agid	1040	8.6	33
	District Total	4281	35.3	136
South Achefer	Lalibela	939	7.7	30
	Ahuri	1039	8.6	33
	Abchikli	1097	9	35
	Kat	1107	9	35
	District Total	4182	34.4	133
Grand Total		12142	100	385

Source: Each Districts Office of Agriculture and Rural Development (2017)

Table 2: Summary of explanatory variables and working hypothesis

Variables	Measurement	Expected effect on market outlets		
		Farm gate	Roadside	Market place
Age of household head	Continuous (No of years)	+	+	-
Gender of household head	Dummy (1 for female, 0 otherwise)	-	-	+
Education level of household head	Dummy (1 literate, 0 otherwise)	+	+	-
Household size	Continuous (no of person)	-	-	+
Vegetables farming experience	Continuous (in years)	+	+	-
Livestock holding	Continuous (in TLU)	+	+	-
Quantity of output sold	Continuous (quintals)	+	+	-
Access to market information	Dummy (1 has access, 0 otherwise.	+	+	-
Credit service	Dummy (1 has got credit, 0 otherwise)	-	-	+
Distance to all-weather road	Continuous (kilometer from home to road)	+	+	-
Crop diversification	Number of vegetable crops	-	+	+
Buyers visit	Dummy (1 visited by buyers, 0 otherwise)	+	+	-

RESULTS AND DISCUSSION

Demographic and socio-economic characteristics

Vegetable producer sample households comprised of 91.4 percent male headed and 8.6 percent female headed households. The average age of the household heads was 42.6 years with a maximum of 70 and minimum of 22 years, indicating that most of the households were in the active age groups. The mean household size of the sample households was 5.9 a little bit higher than the national rural household size of 5.1 and Amhara region household size of 4.6 (**CSA and WB, 2013**). About 30 percent of the total sample household heads could not read and write, and 40 percent of them could only read and write. Sample household heads mean vegetable farming experience was 6.7 years. As indicated in Table 3, sample households average livestock holdings measured in Tropical Livestock Unit (TLU) was 5.8. The maximum holding was 18.2 TLU and the minimum was 0.07 TLU. Based on the survey result, households had allocated on average 0.70 hectares of land for vegetable, ranging from 0.125 to 2 hectares during the survey year (2017). On average a household produced about 33 quintals of vegetables during the survey year. Average gross income (excluding transport cost) of sample households obtained from vegetable production during the survey year was about 19535 Birr.

Market information, buyers visit, and road distance are considered as market access variables in the study. The sample households have different access to market information. On average, 70 percent of the sample households got at least price information from any source before they decided to deliver the produce to market. Another variable taken as a proxy for market access is buyers visit to villages which could be an evidence of the presence of alternative buyers around the rural areas. As indicated in the Table 3, about 36 percent of sample households were visited by buyers at village level. This could increase confidence to farmers related to market risk which in turn motivate farmers to increase marketable perishable crop production. The distance from farmers home to the nearest all weather road is also an alternative measure for market access. This variable measures the road access. Once the producers reach to the road, they can use vehicle or cart to easily transport the produce to market or they can sell their produce at road side. The result of the survey indicated that the average distance to the nearest all weather road was about 5 kilometers with the standard deviation of 3.12. The above market access variables indicated that farmers are required to exert considerable effort to take the produce to the road and market.

Market outlet choice pattern of sample households

The alternative market outlets available to vegetable producers in the study area include farm gate, roadside, market place and home. About 21.3 percent of vegetable producer households exploited farm gate as one of their alternative market outlets. Relatively small number of vegetable producers (17.7%) selected roadside as an alternative market outlet (Table 4), may be due to inaccessibility of road. Market place was the main market outlet where 95.8 percent of sample vegetable producers were participated. It can be the district town market or market within the local peasant administrative areas where any quantity of vegetable produce can be supplied. Very few farmers (2.3%) were also able to sell their vegetable produce at home. Vegetable producers were also found to choose one or more market outlets simultaneously. As shown in Table 4 about 37 percent of sample households sold their produce through only one market outlet. About 17 and 9 percent of households used a combination of 2 and 3 market outlets jointly, respectively.

Effect of outlet choice on productivity and income

Smallholder farmers are used to sell their produce for one or more combination of market outlets depending on their objectives and availability of market outlets. One of their objectives might be earning higher income. This study was expected to find variation in income and productivity of vegetable producers choosing different market outlets. Hence, income and productivity of sample households under different market outlet choices were compared. About eight combinations of market outlets were found to be chosen by sample households, but some combinations were used by only few numbers of households. For example, two households chose all four outlets; farm gate, roadside, local market and home outlet, and six households used both farm gate and roadside. Hence, including very few observations for some combinations for statistical test may not be reliable. So for testing the effect of market outlets on productivity and income using F-test, roadside and home outlets were considered as similar with farm gate outlet. The justification is that significant variation among market outlets is expected on their transportation cost. Transportation cost at home and roadside outlet might be as low as farm gate transport cost compared with local market outlet. Thus, three combinations of market outlets i.e. farm gate, local market and combination of farm gate and local market were taken in to consideration. The result of F-test shown in Table 5 confirmed that the mean value of both yield and income of households significantly varied among these market outlets. Those households choosing both farm gate and local market outlets are found at higher level of yield and income followed by only farm gate sellers. The result indicates that better access to alternative market outlets could improve vegetable productivity and income of smallholder farmers.

Determinants of vegetable market outlet choice

Because home market outlet was hardly selected by households, only farm gate, roadside and market place outlets were considered in the econometric model. The result of the multivariate probit econometric regression is presented in Table 6. As presented in the regression output, the Likelihood ratio test is significant at 1 percent implying that the null hypotheses of all the rho values ($\rho_{12}=\rho_{13}=\rho_{23}=0$) are jointly equal to zero or all the three market outlet choices are independently determined is rejected. The chi^2 test reported in Table 6 verifies that separate estimation of market outlet choices is biased and the decisions to choose the three market outlets are interdependent household decisions. Individual *rho* values indicate the degree of correlation between each pair of the dependent variables. The result of the model showed that the correlation between the choice for market place and farm gate (ρ_{21}) and correlation between the choice for market place and roadside (ρ_{23}) are both negative and statistically significant at less than1% significant level. This finding indicates that farmers selling to the market place are less likely to sell to roadside and farm gate. Likewise, the correlation between farm gate and roadside sell (ρ_{32}) is positive and significant, leading to the conclusion that those selling their vegetables at farm gate are more likely to participate in roadside sale.

The model also showed that the probability of selling vegetables to farm gate and roadside were 21.3 and 19.2 percent, relatively very low as compared to the market place outlet which was 95.5 percent. This may be due to less accessibility of farm gate and roadside sales for vegetable producers in the study area. The probability of vegetable producers to select all market outlets jointly was 7.2 percent indicating that households were unlikely to succeed to choose the three market outlets at the same season.

The results in Table 6 also showed that two variables, buyers visit and age of household head, simultaneously determined all market outlets decision of producers. As shown in the model result, the variable, buyers visit influenced farm gate and roadside outlet positively, and market place outlet negatively showing that producers who were visited by buyers before harvest are more likely to sell at farm gate and roadside, and less likely to take the produce to market place. The implication is that access to farm gate and roadside outlets could reduce transaction cost and market risks associated with perishability of the produce. The second variable which jointly determined all market outlets was age of household head. Higher age was assumed to favor selling at farm gate compared to market place and roadside because market place sale needs more energy in transporting the produce to market areas. However, contrary to the hypothesis, old age drives producers to be reluctant to sell to farm gate and roadside, rather it increases the likelihood to choose market place in selling vegetables. The reason might be that aged farmers are more uncertain about crop price because of uneasy access to information technology. In addition, old aged farmers may establish long lasting clients or customer buyers which would make market place sale less risky. **Xaba and Masuku (2013)** also found that aged cabbage farmers are reluctant to adopt new market channels.

Table 3. Summary of descriptive statistics

Variables	Mean	Std. Dev.	Minimum	Maximum
Age of household head	42.6	8.61	22	70
Gender of household head	0.086	0.28	0	1
Education level of household head	0.70	0.458	0	1
Household size	5.94	2.01	1	13
Vegetables farming experience	6.67	4.16	0	25
Livestock holding (TLU)	5.8	2.66	0.07	18.2
Access to market information	0.7	0.46	0	1
Credit service	0.3	0.46	0	1
Distance to all-weather road (km)	5.05	3.12	0.47	21
Crop diversification	2.76	1.06	1	4
Buyers visit	0.36	0.48	0	1
Weighted output in quintal	32.62	25.66	.72	148.85
Land in hectare	.70	.469	.125	2
Total output per hectare	48.75	24.12	2.88	134.46
Log of net income in Birr	9.88	0.889	5.84	11.80

Source: Author's computation from sample survey data (2017)

Table 4: Market outlets and household choices

Market outlet	Number of users (%)	Number of market outlets	Number of users (%)
Farm gate	21.3	1	73
Local market	95.8	2	17.4
Road side	17.7	3	9.1
Home	2.3	4	0.52

Source: Author's computation from sample survey data (2017)

Table 5: Sample household's yield and income comparison by market outlets

Variable	Farm gate (n=16)	Market (n=271)	Farm gate & market (n=98)	F=test
Yield (output/ha) mean	52.96 (16.585)	45.63 (22.247)	56.69 (28.088)	8.12***
Log of net income in Birr (mean)	9.92 (0.717)	9.81 (0.8495)	10.05 (0.999)	2.68*

Note; Figures in parenthesis are standard deviation
Source: Author's computation from sample survey data (2017)

Table 6: Results of multivariate probit model

Variables	Farm gate Coefficient	Std.Err	Market place Coefficient	Std.Err	Roadside Coefficient	Std.Err
Age	-0.0339***	0.0111	0.0438**	0.0188	-0.0239**	0.0097
Sex	-0.3128	0.3911	1.7893	47.7660	-0.3632	0.3396
Education level	-0.2931	0.1979	-0.7054**	0.3450	-0.0786	0.1870
Household size	0.0531	0.0596	0.0777	0.1063	0.0256	0.0550
Farming experience	-0.0212	0.0248	-0.0341	0.0455	-0.0275	0.0236
Livestock holding (TLU)	0.1188***	0.0383	-0.1335*	0.0732	-0.0350	0.0366
Credit	-0.2061	0.1937	0.5697	0.3584	-0.1119	0.1807
Diversification	-0.2770***	0.0940	0.4887**	0.2016	-0.0169	0.0915
Market information	0.7866***	0.2351	0.0137	0.3604	0.1664	0.2040
Buyers visit	0.8902***	0.1698	-0.6526**	0.3018	0.4148**	0.1677
Distance to all-weather road	-0.0650**	0.0301	0.1370	0.0851	-0.0689**	0.0292
Output	0.0014	0.0041	-0.0099	0.0069	0.0153***	0.0037
Predicted probability	0.2128		0.9555		0.1918	
Joint probability (success)			0.0716			
Joint probability (failure)			0.0013			
Observations 385						
ρ21 -.8992***(.1238)						
ρ31 .6065***(.0711)						
ρ32 -.5177*** (.1300)						
Wald $chi^2(33)$ 344.44***						
Likelihood ratio test (H_0: rho21 = rho31 = rho32 = 0): $chi^2(3)$ = 72.59***						

Note: ***, ** and * indicate the level of significance at 1, 5 and 10 percent, respectively; Figures in parenthesis are standard error
Source: Author's computation from sample survey data (2017)

Livestock holding influenced farm gate sale positively, and market place sale negatively, indicating that farmers with large livestock herd tend to prefer farm gate, than market place. The reason may be high opportunity cost of labor for market place outlet given that livestock herding consumes additional labor for crop producers. The result of the model also indicated that farmers producing diversified vegetable crops were negatively influenced to sell at farm gate and positively influenced to decide to sell at market place. The possible reason might be that farm gate buyers (wholesalers and assembles) require relatively large volume of produce, and diversified crop producers supply small quantity of each crop which is not suitable for farm gate buyers. Another reason could be that diversified producers supply different crops at different harvest time. This would increase the cost of searching farm gate buyers. Hence, involving in diversified crops could decrease the possibility to exploit farm gate outlet as an alternative.

As expected, the variable market information in the model was found positively and significantly determining the decision on farm gate sale. It means that those who were able to get market information are more likely to sell at farm gate. The information could reduce price uncertainty and increase negotiation power of farmers in their farm. **Geoffrey (2015)** indicated that those farmers getting price information are less likely to sell at urban market perhaps to avoid high transaction cost at distant market.

Distance to all-weather roads was expected to favor farm gate sale, because as the distance of farmers' farm gets far from road, they tend to decide to sell at farm gate. However, the result is in contrary to the expectation that it affects farm gate and roadside outlets negatively and significantly. It means that as the distance of the farm increases from all-weather road, producers were less likely to choose farm gate and roadside to sell their produce. The reason might be that farm gate buyers may not get comfortable to go into producers' field far from road due to high cost of transport or high risk associated with poor road. This leads to the conclusion that those producers far from all-weather road could not have market outlet access to choose. Similar result was found by **Giacomo, Chittur and Bhavani (2014)** that remote farm households (furthest from local markets) are more likely to travel to the market may be the consequence of farm gate buyers not being prepared to travel to remote areas for which they may have to incur higher proportional transaction costs.

CONCLUSIONS

The result of F-statistics indicated that productivity and income of sample households varied under different market outlet choice. Those households who used both farm gate and local market outlets simultaneously are found at higher level of income and productivity. In addition, the result of the multivariate probit model showed that the decisions to choose the three market outlets are interdependent household decisions. Decision on farm gate and roadside outlets are positively correlated, and negatively correlated with market place outlet. Two variables, buyers visit and age of household head, simultaneously determined all market outlets decision of producers. Producers who were visited by buyers before harvest are more likely to use farm gate and roadside outlets, and less likely to take the produce to market place. Old age farmers preferred market place outlet than farm gate and roadside outlets perhaps because of lack of access to price information or they established long lasting clients. In addition, livestock holding and market information positively influenced farm gate outlet and diversification and distance to road affected farm gate outlet negatively. It means that as the distance of the farm increases from all-weather road, producers were more likely to transport their produce to market place due to inaccessibility of farm gate and roadside outlets. Improving access to various market outlets through the expansion of roads and communication infrastructure could ease marketing of perishable vegetables. Moreover, local governments at peasant administration or district level should try to bring experienced and younger farmers together under experience sharing forums to share their farm practice knowledge and techniques of accessing market information.

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REGULAR ARTICLE

DOES HUMAN CAPITAL EXPLAIN FOOD INSECURITY STATUS OF RURAL HOUSEHOLDS OR VICE-VERSA?

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ABSTRACT

Food security and human development are intricately linked and no meaningful progress can be sustained without an affiliated progress on the other. Fighting food insecurity therefore requires an increase in the level of human capital. However, food insecurity and low level of human capital development are major challenges among the rural milieu in Nigeria. The effect of human capital on food insecurity status among rural households in Nigeria was therefore investigated in this study. Principal Component Analysis was used to generate human capital index which comprised age, age squared, education, number of inactive days and body mass index of the household head. Household heads that had medium level of human capital were food secure. Human capital index, household size, being a male-headed household, membership of association, land ownership and access to extension significantly reduced food insecurity. Although human capital index had a negative effect on food insecurity, there was no bicausality between them.

Keywords: Dietary diversity, human capital, bicausality, rural Nigeria
JEL: J24, I10

INTRODUCTION

Food is the most basic need of man and it provides nutrients, which are indispensable for the maintenance of good health, improvement of wellbeing, and labour productivity (**Ogundari, 2017**). Africa remains the region with the highest proportion of undernourished people in the population, at 29 percent, compared with a 17 percent average for developing countries (**United Nations, 2009**). In addition to chronic hunger and malnutrition, parts of the continent have been hit by sudden crises that create bouts of acute hunger (**Wiggins and Keats, 2009**). Food insecurity in sub-Saharan Africa is characterized by widespread and chronic hunger and malnutrition as well as recurrent and acute food crises. Sub-Saharan Africa is the most vulnerable region to food insecurity and Nigeria is one of the food deficit countries in sub Saharan Africa (**F.A.O, 2015**). However, ensuring food security in developing countries is a global goal (**Offiong *et al.*,** 2016).

Food insecurity has been on the increase in most rural areas in Nigeria (**Oni *et al.*, 2011**) and over 70 percent of the food insecure population in Africa lives in rural areas (**Mwaniki, 2005**). Recent volatility in international food prices, combined with balance of payment difficulties in some food deficit countries, resulted in several countries needing to secure additional food supply through food aid (**Pedro *et al.* 2011**). Food insecurity is measured as a household-level concept that refers to uncertain, insufficient, or unacceptable availability, access or utilization of food (**Habicht *et al.*, 2004**). The African continent is the only region of the developing world to continue experiencing difficulties after the green revolution of the 1970s and 1980s (**Sanchez and Sachs, 2004**). Since the 1970s, food production per capita on the continent has been declining by about 20% (**Ouedraogo, 2005**). To reverse the decline of the agricultural sector on the continent, the assembly of heads of state and Government of the African Union ratified the declaration on agriculture and food security in Maputo in July 2003 (**Conceição *et al.*, 2011**).

Human capital has been identified as a means of increasing productivity and agricultural income thereby reducing food insecurity (**Schultz, 1961**). It has been argued that food security and human development are intricately linked, and that meaningful progress on one cannot be sustained without concomitant progress on the other (**Conceição *et al.*, 2011**). Human capital is built on four pillars viz: education, health and wellness, nutrition and skills (work force and employment) (**Fafchamps and Quisumbing, 1999**). Low or lack of education reduces opportunities available to households to undertake high income paid jobs. It restricts households to low income jobs (menial jobs) and this makes the household unable to acquire resources to purchase food for consumption thereby increasing the level of food insecurity among the households. Poor health result from lack of health facilities which are a constant feature of most rural areas in Nigeria. Possession of skill increases the opportunity available to household members as it increases their ability to engage in multiple jobs to acquire more income to feed their household members. Hence lack of skill makes people in the households unqualified for certain jobs which invariably reduce income available to the household members' thereby increasing food insecurity among the households. The problem of food insecurity especially during the hungry period among rural households in Nigeria is long standing (**Obamiro *et al.*, 2005**). Thus, since about half of Nigeria's living in rural areas (World Bank 2018), an examination of the factors associated with food insecurity status of rural households in Nigeria is pertinent if progress is to be made towards achieving the second Sustainable Development Goal of zero hunger.

A lot of work has been done on rural household food insecurity in rural Nigeria (**Ajani, 2010; Ayantoye *et al.*, 2011; Adepoju and Adejare, 2013; Agbola, 2014; Ogundari, 2017**), however there is a paucity of information on its relationship with human capital. This study adds to existing literature by investigating the bicausal effect of human capital on food insecurity status of rural households in Nigeria. Achieving food security is a core Sustainable Development Goal (SDG) and achieving improved level of human capital is also a component of the SDG. This study investigated how human capital affects food security status of rural households.

DATA AND METHODS

The study made use of the general household survey 2015 data set carried out by the National Bureau of statistics. The information used for this study are the socio-economic characteristics such as age (years), gender, education (years of formal education), household size, marital status, occupation, per capita income, access to extension, access to credit, farm size, land ownership, geo political zones, membership of association. The study made use of a two-stage sampling design for the survey. In the first stage, Enumeration Areas (EAs) were selected based on probability proportional to size (PPAs) in each state and Federal Capital Territory and total household in those EAs. The second stage involved a selection of households.

The food security status was measured using dietary diversity score into low and high diversity which afterwards was profiled across household socio-economic characteristics. The various food consumed by the households were grouped into twelve categories. The twelve food groups included in the HDDS were: (1) Cereals (maize, rice, millet and sorghum); (2) Roots and Tubers (yam, cassava, cocoyam and sweet potato); (3) Fruits (orange, pawpaw, banana, mangoes, watermelon, apples, avocado and pineapples); (4) Vegetables (Amaranths, onions, tomatoes and okra); (5) Meat and Poultry (chicken, beef, goat or sheep and bush meat, duck); (6) Eggs; (7) Fish (fresh fish, smoked fish, frozen fish, dried fish); (8) Pulses, Legumes and Nuts (cowpea, groundnut, cashew nut); (9) Milk and Milk products (fresh milk, cheese, milk powder, tinned milk); (10) Oil (groundnut oil, red palm oil, coconut oil, butter/margarine, sheabutter, animal fat); (11) Sugar (jam. honey); (12) Condiments (pepper, salt and spices) (**FAO, 2007**). These food groups were used to identify food intake quality of the households. Households that consumed a given category of food were given a value of 1 and 0 in the food categories that they do not consume.

The data used for this study comprised variety of foods and drinks from twelve food groups consumed by the households as a whole during the previous 24 hours. Every food item in the meals was coded. Dietary diversity was measured by summing the number of foods or food groups consumed over a reference period. The HDDS which ranged between 0-12 was used to measure household's dietary diversity and also ranked accordingly into high dietary diversity or food secure (6-12 = 1) and low dietary diversity or food insecure (< 6 = 0) (**FAO, 2008**).

Instrumental Variable (IV) probit model was used to assess bicausality between human capital and food insecurity status among households in rural Nigeria.
The IV probit is specified as in Eq. 1.

$$Y_I = \alpha_i + \beta X_i + \mu_i \qquad (1)$$

Where: Y is dependent binary variable (food insecurity status = 1 and 0, otherwise); β is KX_1 vector; X is nXK matrix of covariates; μ is Error term.

Probit model can be biased because of endogeneity. In essence the correlation between the regressor and the error term is not zero (E(X, U) $\neq$0), so the result of the estimation is inconsistent. So as to overcome this, instrumental variables were applied. Therefore, the model was written in it reduced form (Eq. 2, Eq. 3).

$$Y_{1i}^{*} = \beta Y_{21} + YX_{1i} + \mu_i \qquad (2)$$
$$Y_{21} = X_{1i}\pi_1 + Z_{2i}\pi_2 + V_i \qquad (3)$$

Where:
Y_{1i}^{*} denotes the dependent variable for the ith observation (it answers the question if the household is food insecure or not);
Y_{zi} denotes a vector of endogenous variable; X_i exogenous variable which comprises; X_1 Human capital index; X_2 Household size; X_3 Membership of association (yes = 1, 0 if otherwise); X_4 Farm size (Acres); X_5 Gender (male = 1, 0 if otherwise); X_6 Marital status (married = 1, 0 if otherwise); X_7 Per capita income (₦); X_8 Occupation (Agriculture = 1, 0 if otherwise); X_9 Access to credit (yes = 1, 0 if otherwise); X_{10} Access to extension (Yes 1, 0 if otherwise); X_{11} Land ownership; X_{12} North Central; X_{13} North East; X_{14} North West; X_{15} South East; X_{16} South South; X_{17} South West (Base).

RESULTS AND DISCUSSION

Food insecurity profile across household's socio-economic characteristics

Food insecurity which is our dependent variable was determined using Dietary Diversity Score (DDS). **Agada and Igbokwe (2015)** defined dietary diversity as the number of different foods or food groups consumed by the household over a reference period not regarding the frequency of consumption. It is an outcome measure of food security at the individual or household level. In the present study dietary diversity refers to the number of food groups consumed at household level over a 24-hour period. About 83.02 percent of the respondents had low dietary diversity, while 16.98 percent had high DDS (food secure) (Table 1). This implies that majority of the respondents were food insecure (low DDS).

Households with elderly heads (> 75 years) had the highest proportion of households with low (2.45 percent) and high (2.87percent) DDS groups while those between 31 – 45 years were the highest in both groups (37.77and 35.41 percent, respectively) (Table 1). This implies that household heads between 31 – 45 years age group had the highest dietary diversity and were more likely to have more than six (6) combinations of food categories compared to others. The highest proportion of food insecure (84.44 percent) and food secure (87.56 percent) households were the male-headed. However, a higher percentage of both male and female-headed households were food insecure (low DDS).

Further, in the low dietary diversity category, 74.46 percent and 25.54 percent of the married and unmarried households respectively had low diversity, while 74.16 percent of the married household heads had high diversity and 25.84 percent of the unmarried household heads also had high diversity. This implied that the unmarried household heads had low diversity compared to the married household heads. This is consistent with the findings of **Obayelu and Awoyemi (2010)**; **Grobler (2015)** that households with unmarried heads were less food insecure than their married counterparts. The least proportion (17.51 percent) of households with low DDS were large (>10 members) while those with 7 to 10 members had the highest proportion (37.57 percent). Conversely, the least (17.22 percent) proportion food secure (high DDS) had less than four members while those with 7 to 10 members had the highest (43.06 percent). This suggested that household that had 7 to 10 members were likely to be more diverse in their food category compared to other household sizes. A larger proportion of the household heads in both low and high DDS categories had no formal education.

A larger percentage of the rural household heads were primarily farmers representing 86.79 percent and 89.47 percent of food insecure and food secure household, respectively (Table 2). This invariably revealed food security paradox in rural Nigeria. Although most rural households were agrarian, they were food insecure. A majority (88.95 percent) of the rural households had no access to extension services representing 89.14 percent and 88.04 percent of households in both low and high DDS, respectively. Similarly, a majority (81.88 percent) of the rural households had no access to credit representing 83.86 percent and 72. 52 percent of households in both low and high DDS, respectively. This indicated that most of the rural households had no access to productive assets like extension services and credit which is responsible for low level of investment and output and consequently low economic access to diverse food items.

Table 1: Food security profile by demographic characteristics of household heads

Demographic characteristics	Dietary Diversity Categories		
	Low (N =1022)	High (N =209)	Total (N = 1231)
Age of household head (in years)			
< 30	43(4.21)	17(8.13)	60(4.87)
31 – 45	386(37.77)	74(35.41)	460(37.37)
46 – 60	372(36.40)	70(33.49)	442(35.91)
60 – 75	196(19.18)	42(20.10)	238(19.33)
>75	25(2.45)	6(2.87)	31(2.52)
Gender			
Male	863(84.44)	183(87.56)	1046(84.97)
Female	159(15.56)	26(12.44)	185(15.03)
Marital status			
Married	761(74.46)	155(74.16)	916(74.41)
Unmarried	261(25.54)	111(25.84)	315(25.59)
Household size			
1 – 3	195(19.08)	36(17.22)	231(18.77)
3 – 6	264(25.83)	40(19.14)	304(24.7)
7 – 10	384(37.57)	90(43.06)	474(38.51)
>10	179(17.51)	43(20.57)	222(18.03)
Level of formal education of household head			
No formal	407(39.82)	75(35.89)	482(39.16)
Primary	308(30.14)	54(25.84)	362(29.41)
Secondary	205()	45()	250()
Tertiary	102	35	137

Table 2: Food security profile by economic characteristics of household heads

Economic variables	Dietary Diversity Categories		
	Low (N=1022)	High (N = 209)	Total (N = 1231)
Occupation			
Agriculture	887(86.79)	187(89.47)	1074(87.25)
Non-agriculture	135(13.21)	22(10.53)	157(12.57)
Access to extension			
No	911(89.14)	184(88.04)	1095(88.95)
Yes	111(10.86)	25(11.96)	136(11.05)
Access to credit			
No	857(83.86)	151(72.25)	1008(81.88)
Yes	165(16.14)	58(27.75)	223(18.12)
Land ownership			
No	260(25.44)	44(21.05)	304(24.70)
Yes	762(74.56)	165(78.95)	927(75.30)
Farm size (in ha)			
< 1	960(93.93)	185(88.52)	1145(93.01)
1 – 5	61(5.97)	23(11.00)	84(6.82)
> 6	1(0.10)	1(0.48)	2(0.16)
Per capita annual income (₦)			
< 20000	450(44.03)	97(46.41)	547(44.44)
20001 – 40000	367(35.91)	76(36.36)	443(35.99)
40001 – 60000	40(3.91)	6(2.87)	46(3.74)
60001 – 80000	61(5.97)	10(4.78)	71(5.77)
>80000 ($222.2)	104(10.18)	20(9.57)	124(10.07)

About three-quarters of household with low DDS owned land while 78.95 percent of those with high DDS were land owners (Table 2); implying that those households that owned land were more likely to be slightly food secure than landless household heads that do not own any land. This may probably be due to the fact that they can produce different varieties of crops on their land and this in turn gave them access to an array of food crops they could grow and consume daily. Further, the majority (93.01 percent) of households were smallholder farmers representing 93.93 percent and 88.52 percent of households with low and high DDS, respectively. A larger percentage of the rural households were living in chronic poverty (less than $1/day = < N80, 000/day). Consequently, smallholder agriculture characterised with small land holdings with no land property right, low per capita income, lack of access to credit and extension services explains high level of low dietary diversity scores in rural Nigeria.

Further, the South-south geopolitical zone had the highest contribution to low dietary diversity (Table 3). This could be explained be low level of farming and fishing livelihood activities owing to oil spillage in the South-south. Low level of livelihood is expected to erode household welfare and dietary diversity. Although the incidence of low dietary diversity was higher than high dietary diversity in all the geopolitical zones, Northwest had the highest contribution to high dietary diversity. The Human Capital Index (HCI) was categorised into three groups. This comprised low (<0.33), medium (0.33<HCI<0.66) and high (>0.66) human capital categories. While 22.97 percent of the households that had low human capital, 39.23 percent of the households that had medium human capital and 37.80 of the household head that had high human capital had high dietary diversity. This implies that household heads that had medium level of human capital the high dietary diversity compared to household with other categories of human capital.

Table 4 presented the results of Instrumental Variable (IV) probit regression analysis on the test of endogeneity between human capital and food insecurity among households in rural Nigeria. The positive sign of a coefficient implies that an increase in the value of an independent variable increases the probability of a household being food insecure (decreasing food security) given other factors. Conversely, a negative sign of the independent variable means that an increase in the value of an independent variable reduces the probability of the household being food insecure (increasing food security), given other factors.

Human capital index had a negative relationship with food insecurity. This index was constructed using the Principal Component Analysis (PCA). The analysis of the result showed that an increase in the level of human capital brought about a decrease in food insecurity. This implies that household heads with a level of human capital were less likely to be food insecure thereby increasing the probability of a household being food secure than household heads that lacked human capital. The marginal effect revealed that a unit increase in the level of human capital brought about a decrease in food insecurity by 1.03 units.

Gender of the household head had a negative relationship with food insecurity implying that male-headed households were less likely to be food insecure than female-headed households. This may probably be because in most rural areas, males have more access to productive assets than their female counterparts.

Table 3: Food security profile by geo-political zones and human capital

Variables	Dietary Diversity categories		
	Low (N=1022)	High (N= 209)	Total (N = 1231)
Zones			
North Central	166(16.24)	27(12.92)	193(15.68)
North East	137(13.41)	42(20.10)	179(14.54)
North West	183(17.91)	48(22.97)	231(18.77)
South East	197(19.28)	32(15.31)	229(18.60)
South South	215(21.04)	39(18.66)	254(20.63)
South West	124(12.13)	21(10.05)	145(11.78)
Human capital			
Low	301(29.45)	48(22.97)	349(28.35)
Medium	362(35.42)	82(39.23)	444(36.07)
High	359(35.13)	79(37.80)	438(35.58)

Table 4: Assessment bi-causality between human capital and food security status among households in Rural Nigeria

Food security	Coefficient	Marginal effect
Human capital index	-1.0336***	-1.0336***
	-(10.17)	-(10.17)
Gender	-0.3868**	-0.3867**
	-(1.70)	-(1.70)
Marital status	0.0207	0.0207
	(0.79)	(0.79)
Household size	-0.0935***	-0.0935***
	-(6.24)	-(6.24)
Occupation	-0.0601	-0.0601
	-(0.27)	-(0.27)
Access to extension	-0.3570**	-0.3570**
	-(2.03)	-(2.03)
Access to credit	-0.0758	-0.0758
	-(0.32)	-(0.32)
Membership of association	-0.7868***	-0.7867***
	-(3.99)	-(3.99)
Per capita income	-2.32e-07	4.73e-07
	-(0.47)	(1.11)
Land ownership	-0.3039**	-0.3038**
	-(1.78)	-(1.78)
Farm size	6.42e-06	6.42e-06
	(0.64)	(0.64)
North Central	0.3893***	0.3891***
	(2.56)	(2.56)
North East	0.5171***	0.5171***
	(2.14)	(2.14)
North West	0.5003**	0.5003**
	(2.12)	(2.12)
South East	-0.0485	-0.0485
	-(0.33)	-(0.33)
South South	0.3288**	0.3288**
	(2.30)	(2.30)
Constant	2.3659	
	(4.72)	
Wald chi2(11) = 984.37		
Prob > chi2 = 0.0000		
Log likelihood = -1779.3724		
Number of observation = 978		

Notes: Figures in parenthesis are the z values, *** significant at 1%, ** significant at 5% and * significant at 10%

This will make food to be more available to the household and in essence reduce food insecurity. In addition, larger the household were less probable to being food insecure than those with fewer members. This is because among rural households, an increase in household size will lead to an increase in amount of labour available for farming activities. This will eventually lead to an increase in food production and thereby help in reducing food insecurity among the households. The probability of being food insecure will decrease by 0.09 unit with an additional family member in adult equivalent. This result is contrary to the findings of **Frehiwot (2007)** and **Sekhampu (2017)** that increase in household size exacerbates food insecurity.

Access to extension also had a negative relationship with household food insecurity suggesting that household heads with extension contact were less likely to be food insecure than those without extension contact. Households whose heads belonged to one or more association were less likely to be food insecure than those without any association. This can be closely linked to the beneficial effects of their membership, in terms of production and other welfare enhancing services that were offered by the societies and organizations. It could also be that members of the households in cooperative were given the opportunity to take loans in order to manage their agricultural activities. In addition, land ownership had a negative relationship with household food insecurity indicating that household heads that owned one or more lands were less likely to be food insecure. This may probably be due to the fact that lands in the rural areas were majorly used for agricultural activities. This will avail the households to engage more in farming activities that involves food production. Finally, households residing in North Central, North East North West zone, and South South geopolitical zones had positive relationship with the household food insecurity status suggesting that households residing in these zones were more likely to be food insecure relative to those in South West. The northern regions are known for high prevalence of poverty (**Obayelu and Awoyemi, 2010**) are therefore susceptible to high level of food insecurity.

Weak instrument robust test for instrumental variable ((Riv test) probit regression.

The Riv test is a set of test carried out to test for the strength or weakness of the instrumental variables in IV probit regression. The Anderson Rubin (AR) statistics by (**Anderson and Rubin, 1949**) was used to test for the strength of the instrumental variables. The result showed that the null hypothesis was rejected at 5 percent indicating that the instrumental variable (religion) was not weak (Table 5). The Wald test is a summary of all the test statistics and the result showed that there was no bi-causality between human capital and food insecurity.

Table 5: Riv test of instrumental variables (IV) Probit regression

Test	Statistic	P-value
AR	chi2 (1) = 1.54	Prob > chi2 = 0.2145
Wald	Chi2 (1) = 103.51	Prob > chi2 = 0.0000

CONCLUSIONS

The food security profile showed that household heads that had medium level of human capital were more food secured. Household size, membership of association and access to extension significantly influence human capital. The result revealed that there was no endogeneity between human capital and food insecurity. The study also found out that human capital index which comprises age, age squared, education, number of inactive days and body mass index though not significant, had a negative relationship with food insecurity such that as human capital increases, food insecurity decreases. Based on the findings from the study that investment in human capital (health, education, nutrition and skills) helps in reducing food insecurity. Likewise access to credit and extension services give the rural people the opportunity of involving in activities that aids in building their human capital base thereby reducing food insecurity. It is therefore suggested that governments at all levels should intensify programmes on human capital development that will improve human capital base in rural Nigeria especially in the Northern zones where food insecurity were more endemic. Furthermore, market-based intervention policies such as access to credit facilities, that facilitate households' livelihood activities and access at all times to healthy foods of their choice, should be given priority. This will give the household opportunity to benefit from greater varieties of food items offered by the market. Government should provide comprehensive extension training programmes that will increase productivity of the rural households and hence reduce food insecurity among the households.

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