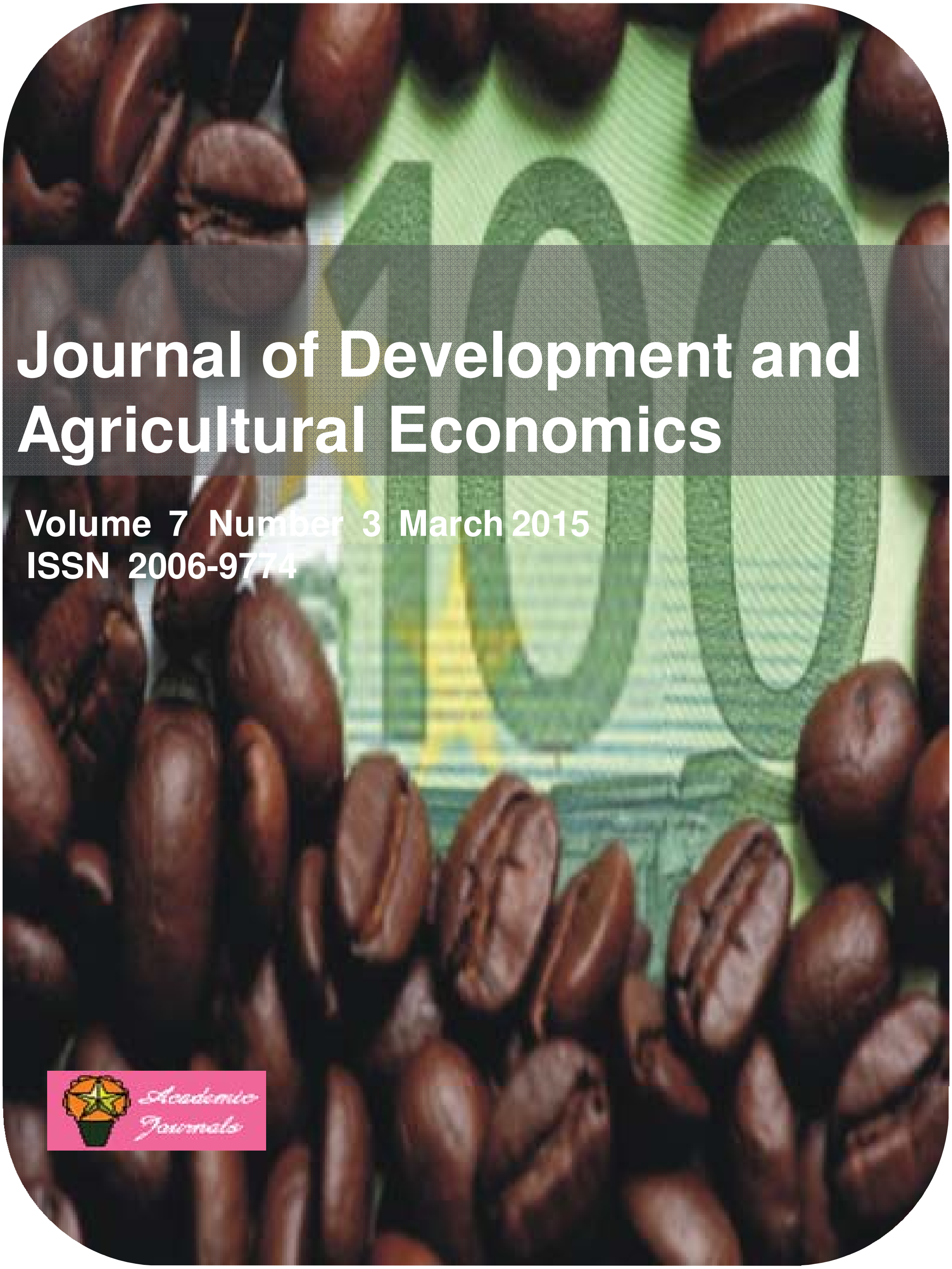

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Table of Contents: Volume 7 Number 3 March 2015

ARTICLES

Research Articles

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Full length Research Paper

Discontinued use decision of improved maize varieties in Osun State, Nigeria

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The study investigated the level and socioeconomic determinants of discontinued use decision of improved maize varieties among farming households in Osun State, Nigeria with a view to increasing food production. A multi-stage sampling procedure was adopted to select a sample of 321 farmers across the three agro ecological zones of the State. Data were collected using a pre-tested structured questionnaire and interview schedule. Data were collected on demographic and socioeconomic characteristics of respondents such as age, household size, gender, farm size and other maize production related activities including reasons for discontinued use of improved maize varieties. Data were analyzed using descriptive statistics and bivariate probit model. Results showed that 51.7% of households that initially adopted improved maize varieties (IMVs) discontinued their use while only 48.3% continued using them. Off-farm income (t=2.09; p<0.05), frequency of extension services contact (t=10.43; p<0.05), membership in associations (t=2.59; p<0.05) and level of education (t=2.66; p<0.05) significantly influenced the discontinued use decision of improved maize varieties by the farm households. The study concluded that improved farmer education and access to effective and efficient extension delivery services are capable of ensuring continued use of IMVs and increasing maize production in Osun State.

Key words: Discontinued use, improved maize varieties, bivariate probit model.

INTRODUCTION

Maize (*Zea mays*) is one of the major cereal crops in Nigeria. In addition to its nutritional value, maize generates employment and creates income opportunities for resource poor households. Maize is the third most important cereal crop in the world after rice and wheat, and the most important cereal crop in Sub-Saharan Africa (SSA) with regard to cultivation area and total production and an important staple food for more than 1.2 billion people in SSA and Latin America (IITA, 2013). It accounts for approximately 20% of domestic food production in West and Central Africa, Nigeria inclusive (Kamara et al., 2006). It therefore contributes to food security and poverty reduction among the rapidly growing population.

The importance of farmers' adoption of new agricultural technology has long been of interest to agricultural economists, extensionists and rural sociologists. It is believed that an effective way to increase productivity and enhance peoples' livelihoods is broad based adoption of new farming technologies (Mitten and Barret,

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2008). For instance, a study in Mexico showed that adoption of improved maize varieties improves household welfare (Beceril and Abdullah, 2010). Similarly, in sub-Saharan Africa, adoption of improved maize was indicated to have positive outcomes (Alene et al., 2009). Maize average yield in Nigeria is still low compared to its potential yield (Kudi et al., 2011) despite several agricultural policies and programmes aimed at increasing productivity adopted by the government to ensure improved food security such as the Presidential initiative of doubling maize production. World Bank (2008) asserted that the low adoption of productivity enhancing technologies undermines efforts to reduce rural poverty in most countries in Africa, Nigeria inclusive.

However, it is one thing to adopt a new technology; it is another thing to continue the use of the newly adopted technology. Thus, an important component of the technology adoption decision making process which has received little research attention is discontinued use decision otherwise known as disadoption which is the decision to reject a particular technology after a period of adoption. For example, the adoption of improved maize seeds occurs if the expected net marginal benefit of adoption exceeds zero (Saha et al., 1994). Moreover, a household decides to continue the use of improved maize seeds in a particular year only if the use of the technology can generate a net gain (Carletto et al., 1999). Technologies that are abandoned (discontinued) are just as ineffective as technologies not adopted. By identifying constraints that will lead to the eventual rejection of a technology, extension programmes can be better designed. A large number of studies have considered the rate, timing and extent of adoption of agricultural innovation (Feder et al., 1985; Sunding and Zilberman, 2001) with few studies considering technology abandonment (discontinued use). The act of not taking discontinued use decision of farmers into consideration implies an assumption that adoption is irreversible; whereas adoption of improved technologies will not improve food security and reduce poverty if barriers to their continued use are not overcome Oladele (2005). This is particularly important for major staple crops such as maize. Though, Kolawole et al. (2003) reported varying degrees of discontinuance among farmers in Ekiti State, Nigeria to be immediate, gradual and rapid, based on the nature of innovations and farmers' situation. Some few studies exist on reasons why farmers discontinue the use of already adopted technology (Neill and Lee, 2001; Aklilu and De Graaf, 2007; and An, 2008), little has been said about the level of and determinants of discontinued use decision of agricultural technologies such as improved crop varieties.

Hence, this paper specifically assessed the level of discontinued use of improved maize varieties, identifies reasons for discontinuity and analyzed the socioeconomic factors influencing discontinued use decision of improved maize varieties in Osun State, Nigeria.

METHODOLOGY

Study area

The study was conducted in Osun State. The State is located in the Southwestern part of Nigeria and lies between latitude 05° 58'N and 08° 07'N and longitude 04° 00'E and 05° 05'E. The State covers a total land area of approximately 14,875 km^2 with a total population of 3,423,535 with sex distribution of 1,740,619 male and 1,682,916 female and population density of 238.1/km^2. The state has three agro ecological zones (AEZs) namely rain forest (Ife/Ijesa), derived savannah (Osogbo), and savannah (Iwo) zones with six administrative zones.

The climate is tropical and characterized by a bi-modal rainfall pattern, the raining and the dry seasons. The annual rainfall ranges from 800 mm in the derived savannah to 1500 mm in the rain forest while the mean annual temperature varies from 21.1 to 31.1°C (OSSG, 2004). The state's soil type is of the highly ferruginous tropical red soil and the vegetation is mostly rainforest that is suitable for maize production.

Sampling procedure, sample size and data collection methods

A multi-stage sampling procedure was used to select respondents. Four Local Government Areas (LGAs) noted for maize production were purposively selected in each of the three agro-ecological zones (AEZs) in the state. This was followed by selection of twelve villages across the selected LGAs based on the proportion of high maize producing villages in each LGA. Simple random sampling was then used to select a total of three hundred and twenty one (321) IMVs adopting farmers proportionately across the selected villages based on the formula by Yamane (1967).

Using sampling procedure formulated by Yamane (1967) and adopted by Israel (2009), a total of 397 sample size will be employed in the study. The operationalized statistical formula developed by Yamane (1967) is stated as follows:

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

Where, n = anticipated total sample size; N = population size; e = acceptable error term (0.05). Therefore, the total sample size was computed as:

$$N = \frac{1625}{1 + 1625\,(0.05)^2}$$

n = 321

The selected farmers were then categorized using stratified sampling into continued and discontinued users of improved maize varieties to give a total of 166 discontinued users and 155 continued users for the study.

Primary data were collected using a structured and pretested questionnaire. Data collected included household socioeconomic characteristics such as age, gender, marital status, farm size, and education. Data were also collected on the level of awareness, discontinued use of improved maize varieties and reasons for discontinuity. Data were collected during the 2012 growing season.

Data analysis

Both descriptive and inferential statistics were used to analyze data obtained. Descriptive statistics used included means and percentages to describe the socioeconomic characteristics of the respondents and assess the level of awareness and discontinued use while bivariate probit model was used to analyze the socioeconomic factors influencing discontinued use decision of improved maize varieties.

In this study, a farmer is said to be a discontinued user, if he or she had used improved maize seed in the last three years including 2011 cropping season. Since adoption occurs before continuation or discontinuation, the model is specified based on the assumption that discontinued use is likely to be impacted by the various factors that influence adoption (Wendland and Sills, 2008). In technology abandonment (discontinued use), farmers will make two interrelated discrete decisions. First, farmers make decisions as to whether to adopt or not to adopt a technology; then they decide to either continue or discontinue its use (abandonment).

A farming household decides to discontinue the use of an agricultural technology if reducing the area planted with the technology to zero creates a utility gain (Carletto et al., 1999).

A two staged probit (bivariate probit) model was specified for adoption and discontinue use decision (disadoption) of improved maize varieties. These were then applied sequentially to regress the variable that explains the likelihood of adoption as well as the probability of discontinued use. Hence, farmers are grouped as 'adopters' and 'non adopters' in the first stage of biprobit analysis, and as 'continued user' and 'discontinued user (disadopter)' in the second stage of the analysis.

Following Greene (1993), denoting Y^*_{i1} and Y^*_{i2} as change in utility due to adoption and discontinued use of improved maize varieties respectively. The model is specified as follows:

$$Y^*_{i1} = \beta_1 X_{i1} + \varepsilon_{i1},\ Y_{i1} = 1 \text{ if } Y^*_{i1} > 0 \text{ and 0 otherwise} \quad (1)$$

$$Y^*_{i2} = \beta_2 X_{i2} + \varepsilon_{i2},\ Y_{i2} = 1 \text{ if } Y^*_{i2} > 0 \text{ and 0 otherwise} \quad (2)$$

$$E[\varepsilon_{i1}] = E[\varepsilon_{i2}] = 0 \quad (3)$$

$$Var[\varepsilon_{i1}] = Var[\varepsilon_{i2}] = 1 \quad (4)$$

$$Cov[\varepsilon_{i1}\varepsilon_{i2}] = \rho \quad (5)$$

(Y_{i1}, X_{i1}) is observed only if $Y_{i2} = 1$, where Y^*_{i1} and Y^*_{i2} are underlying latent variables; Y_{i1} =1 if the farmer adopts improved maize seed, 0 otherwise (never adopts); Y_{i2} =1 if the farmer discontinue the use of improved maize seed, 0 otherwise (continued); β_1 and β_2 are vectors of parameters to be estimated, X_{i1} and X_{i2} are vectors of explanatory variables, ε_{i1} and ε_{i2} are normally distributed error terms.

For a given individual, Y_{i2} is not observed unless Y_{i1}=1. Thus, there are three types of observations in a sample with unconditional probabilities. These are:

$$Y_2=0: prob(Y_2=0) = 1 - \Phi(\beta_2' X_2) \quad (6)$$

$$Y_1 = 0,\ Y_2 = 1: prob\ (Y_1 = 0, Y_2 = 1) = \Phi_2\ (-\beta_1' X_1, \beta_2' X_2, -\rho) \quad (7)$$

$$Y_1 = 1,\ Y_2 = 1: prob\ (Y_1 = 1, Y_2 = 1) = \Phi_2\ (\beta_1' X_1, \beta_2' X_2, \rho) \quad (8)$$

Where Φ denotes the univariate standard normal Cumulative Distribution Function (CDF), and Φ_2 denotes the bivariate standard normal CDF. There are three subsamples in the above formulation. The first sets of observations refer to non-adopters. The second group belongs to disadopters, that is, farmers who adopted but discontinued using the technology. The third group comprises households that reported continued use of the technology. Based on these subsamples, the log-likelihood function for a sample of N observations can be expressed as:

$$LogL(\beta_1,\beta_2,\rho) = \sum_{y_1=1\, y_2=1} \log \Phi_2 \left[\beta_1' x_1, \beta_2' x_2, \rho\right] + \sum_{y_1=1\, y_2=0} \log \Phi_2 \left[-\beta_1' x_1, \beta_2' x_2, -\rho\right] + \sum_{y_1=0} \log 1 - \Phi\left[\beta_2' x_2\right] \quad (9)$$

The model parameters are estimated by maximizing this log likelihood function with respect to parameters reported in the study.

The bivariate probit model for analyzing adoption and discontinued use in the study was specified as follows:

$$Y_1 = Y_2 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots. + \beta_{12} X_{12} \quad (10)$$

Where the explanatory variables are defined as follows: X_1 = Education of the household head (years), X_2 = Age of household head (years), X_3= Farming experience (years), X_4= Household size (number), X_5 = Farm size (ha), X_6 = Off-farm income (₦), X_7 = Access to credit (1 if yes, 0 otherwise), X_8 = Frequency of extension service contact (Frequency), X_9 = Distance to market (km), X_{10} = Membership in association (1 if yes, 0 otherwise), X_{11} = Seed availabilty (1 if adequate, 0 otherwise), X_{12}= Land security (1 if secured, 0 otherwise), Y_1= 1 if the farmer adopted improved maize varieties, 0 otherwise, and Y_2 = 1 if the farmer discontinued the use, 0 otherwise, and βs are coefficients of parameters to be estimated.

Test of multicollinearity among the study variables

To examine multicollinearity, a variance inflation factor was conducted. VIF can detect whether collinearity exists or not (no collinearity exists if the VIF is below 10). Table below shows that the VIF values of the independent variables range from 1.28 to 1.92 and have a mean VIF of 1.58. Thus, it can be concluded that no collinearity exists between these variables.

RESULTS AND DISCUSSION

Level of discontinued use of improved maize varieties

The result of descriptive statistics on the adoption and discontinued use of improved maize varieties is presented in Table 1. Out of the 321 households that cultivated (adopted) improved maize varieties, more than half (51.7%) discontinued its use while 48.3 % continuously used the adopted technology (improved maize varieties). Thus, the level of discontinued use was high; the level was expected to rise if improved seeds were not timely made available during growing season.

Reasons for discontinued use of improved maize varieties

Untimely availability of improved seeds (55.4%) during the growing period was the major reason stated by farmers for discontinued use of improved maize varieties as indicated in Table 2. Others were high seed costs (25.3%) and non availability of seed (18.1%). Only 1.2% of the farmers indicated lack of access to extension service as a reason for discontinued use.

Socioeconomic characteristics of respondents

The socioeconomic characteristics of respondents are shown in Table 3. The mean age of the total respondents

Table 1. Multicollinearity diagnosis.

Variable	VIF
Age	1.78
Education	1.73
Years of experience	1.61
Household size	1.28
Farm size	1.57
Access to credit	1.43
Distance	1.45
Extension	1.54
Land security	1.32
Off farm income	1.92
Membership of Association	1.77
Mean VIF	1.58

Table 2. Adoption and discontinued use of improved maize varieties.

Items	Frequency	Percentage (%)
Discontinued users	166	51.7
Continued Users	155	48.3
Total (Number of Adopters)	321	100.0

Source: Field survey, 2012.

Table 3. Reasons for discontinued use of improved maize varieties.

Reasons	Frequency	Percentage (%)
Untimely availability of seeds	92	55.4
High cost of seeds	42	25.3
Non availability of seeds	30	18.1
Lack of access extension service	2	1.2
Total	166	100

Source: Field survey, 2012.

was 59.2±13.3 years which is an indication that the respondents were fairly in their active years. The mean age of the discontinued users category was the highest (57.3±12.1 years) while those that continued the use of improved maize varieties had a mean age of 53.6±12.3 years. The sample households composed of both male and female heads, majority (84.7%) were male headed while 15.3% were female headed. The male headed households' proportion of discontinued users and continued users were 85.5 and 83.9% respectively. This shows that male headed households were higher than female headed households for each category of respondents. 35.1% of the total respondents had no formal education while 23.9, 26.6 and 14.4% completed primary, secondary and tertiary education respectively. If completion of primary school is taken to measure ability to read and/or write, 46.8% of discontinued users could read and/or write, while 53.2% of discontinued users could not. This indicated that the level of literacy is low among the discontinued users category while it was high (72.3%) among the continued users.

The mean year spent in acquiring formal education for the total sample households was about 9.2±6.4 years while it was about 6.1±4.1 years and 8.5±6.4 years for discontinued and continued users respectively. More than half of the respondents (55.1%) were members in one farmers association or the other while, 44.9% were not. Further, within each category, greater percentage of discontinued users (52.4%) were not members in any farmers' association but greater percentage (63.2%) of continued users were member in farmers' association. The mean total farm size of the sampled households was

Table 4. Socioeconomic characteristics of respondents.

Variable	Pooled (n=321)	Discontinued users (n=166)	Continued users (n=155)
Mean age (year)	59.2(13.3)	57.3(12.1)	53.6(12.3)
Sex (%)			
Male	84.7	85.5	83.9
Female	15.3	14.5	16.1
Level of education (%)			
Nil	35.1	53.2	27.7
Primary	23.9	24.7	22.6
Secondary	26.6	20.1	29.7
Tertiary	14.4	2.0	20.0
Mean year of education (year)	9.2(6.4)	6.1(4.1)	8.5(6.4)
Mean farm size (year)	3.1(2.3)	2.4(1.4)	2.5(1.9)
Mean farming experience (year)	32.6(11.6)	37.5(13.7)	26.9(13.7)
Membership in association (%)			
Yes	55.1	47.6	63.2
No	44.9	52.4	36.8
Frequency of extension service contact (%)			
No contact	58.9	94.0	10.0
Weekly	0.3	0.0	1.3
Fortnightly	5.6	0.6	52.9
Monthly	26.8	2.4	21.3
During input and/or			
Credit collection	1.9	2.4	1.6
Occasionally	6.5	0.6	12.9

ha = Hectare; % = percentage; standard deviation in parenthesis.

3.1±2.3 ha. The mean total farm size for discontinued users category was the highest (2.4±1.4 ha) whereas it was 2.5±1.9 ha for continued users. The mean years of farming experience was 37.5±13.8 years for the sample households. The discontinued and continued users' category of the respondents had mean years of 32.6±11.6 and 26.9±13.7 respectively. Most of the sample households (58.9%) responded zero frequency of extension service contact, while 41.1 percent had extension service contact at different levels of frequency. From the discontinued users' category, majority (94.0%) did not have any contact while 6.0% had contact with extension agents. The reverse was the case among the continued users, 10.0% had no contact with extension agents while 90.0% had contact at different levels of frequency.

Factors influencing discontinued use decision of improved maize varieties

The results of the probit model for discontinued use decision of improved maize varieties are presented in Table 4. The level of education, distance to market, frequency of extension service contact, off farm income and membership in association are the statistically significant factors that explained the likelihood of discontinued use of improved maize varieties.

Level of education was negative and statistically significant at 5%. A unit increase in the level of education would likely reduce discontinued use decision by 1.8%. The more educated a farmer is, the lesser the likelihood to discontinue the use of improved maize varieties. Educated farmers are better informed and easily consolidate gains of new innovations thereby reducing their decision to discontinue its use. This agreed with outcomes of previous studies such as Moser and Barret (2003) and Bravo-Ureta et al. (2006).

The distance of farmers' village to the market center was found to be statistically significant and positive at 5%. A unit increase in the distance of the respondents' village to the market center increased the decision to discontinue use of improved maize varieties by 8.5%. By implication, the farther the distance of the respondents' village to the market center, the higher the probability to

Table 5. Probit estimates for discontinued use decision of improved maize varieties.

Variables	Coefficient	Standard error	P- value	Marginal effects	t-value
Age	-.0232	.0169	0.170	-.0075	
Level of education	-.0577**	.0217	0.008	.0175	2.66
Farming experience	.0015	.0168	0.928	.0115	
Household size	.0751	.0602	0.212	.0147	
Farm size	-.0059	.0174	0.733	.0150	
Access to credit	.2933	.2297	0.202	-.0286	
Distance to market	.0901**	.0331	0.006	.0851	2.72
Extension contact	- 2.2630***	.2170	0.000	.0935	10.43
Land security	.0840	.2226	0.706	-.0020	
Off farm income	-.0023**	.0011	0.043	-.0081	2.09
Membership in association	-.2629**	.1016	0.010	.0589	2.59
Constant	-.5035	.7649	0.510		
Athrho	17.60575	1348.758	0.990		
rho	1	2.70e-12			
Log likelihood	-114.0464				
Wald chi2 (24)	197.63				
Likelihood-ratio test of rho	0				

***Significant at 1%; ** = significant at 5%.

discontinue the use of improved maize varieties. This might be as a result of difficulties in transporting harvests to and purchase of required inputs associated with improved maize varieties from the market owing to the bad state of feeder roads in the study area. This finding agreed with the study conducted by Tura et al. (2009).

Frequency of extension service contact was significant and negative. A unit increase in the frequency of extension contact would reduce the likelihood of the discontinued use decision by 9.4%. By implication, the more the frequency of contact, the lesser the probability of taking a discontinued use decision. This might be due to the fact that access to advisory services through extension contact would inform and build the capacity of farmers, increase their knowledge and reduce their uncertainty in decision making. The finding agreed with that of Bravo-Ureta et al., (2006) and Knowler and Bradshaw (2007).

Engagement in off farm activities was negatively significant at 5%. A unit increase in the income from off farm activities would reduce the discontinue use decision by 0.8%. This implies that the more a farmer earns from non-farm activities, the lesser the likelihood of taking a discontinued use decision of improved maize varieties. This could be linked to the possibility of using money from off farm activities for purchasing of inputs necessary to continue growing improved maize varieties. This was in consonance with the findings of Tura et al. (2009) and Bravo-Ureta et al. (2006).

Membership in farmers' association was also significantly negative in determining taking discontinued use decision at 5%. A unit increase in membership of farmers' association reduces probability of discontinued use of improved maize varieties by 5.9%. This may be due to the fact that membership in farmers' association has been found to enhance the interaction and cross fertilization of ideas among farmers thereby furnishing them with gains of consolidating new technologies (Table 5). The finding agrees with the study conducted by Bravo-Ureta et al. (2006).

CONCLUSION AND POLICY IMPLICATIONS

Significance of adoption of new agricultural technologies by farming households cannot be overemphasized as it is generally known that for achieving food security and poverty reduction among the growing populace, improved farming technologies must be available to farmers along with full information on how to use the new technologies (Minten and Barret, 2008). However, it is one thing to adopt a technology, it is another thing to continue using it. Adoption of improved technologies will not improve food security and reduce poverty if constraints to their continued use are not overcome.

The study indicated that discontinued use decision was a significant problem among farming households in the study area. Of the 321 adopting households, more than half (51.7%) were discontinued users. The econometric estimation showed the potential of education, distance to market, and frequency of extension service contact, off farm income and membership in association in influencing the likelihood of discontinued use of improved maize varieties.

Policy intervention that increase farmers' access to education and intensify extension enlightenment campaign by the State Agricultural Development Programme should be put in place. Also, farmers' socioeconomic characteristics should be considered fundamental in designing government intervention strategies in aiding adoption of technologies and their continuous use.

Conflict of Interest

The authors have not declared any conflict of interest.

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Full length Research Paper

Technical efficiency of traditional African vegetable production: A case study of smallholders in Tanzania

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Traditional African vegetables are receiving more attention for their significant contribution to food and nutrition security and enhanced livelihoods of smallholders. Although demand is increasing for these nutrients-dense crops, the production of traditional vegetables in Tanzania remains low. Technical innovations can reduce yield gaps and increase the productivity of traditional vegetable crops. This paper measures the technical efficiency of farm households that produce traditional vegetables in Tanzania using a Cobb-Douglas stochastic frontier production function. This study reports data from a primary survey of 181 households that cultivated traditional vegetables in five regions (Arusha, Tanga, Morogoro, Dodoma and Dar es Salaam) of Tanzania. The results show that overall mean technical efficiency is 67%. It indicates that if the average farmer of the sample could achieve the technical efficiency level of most efficient counterpart, then average farmers of the sample could increase their output by 27% with better use of available production resources given the current state of technology. Farmers were observed to be more technically efficient in the Arusha region than in the other study regions. Possible reasons for the observed regional difference include agroclimatic variability, access to extension services, and infrastructure facilities. A linear relationship exists between farm size and technical efficiency. The study concludes that strengthening farmer associations to encourage knowledge sharing and enhancing the existing cluster approach to farming may help to improve technical efficiency.

Key words: Smallholders, inefficiency, resource use, inputs, technology.

INTRODUCTION

In Tanzania, 80% of households are primarily engaged in the agricultural sector (World Bank, 2014), in which large number of farmers are smallholders (operating on <2 ha) who mostly grow traditional vegetables (Weinberger and Msuya, 2004). Recently, traditional vegetables have received more attention for their

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significant contribution to food and nutritional security and enhanced livelihood of smallholders (Afari-Sefa et al., 2012). Although demand is increasing for these important crops, the productivity of traditional vegetables in most regions of Tanzania is quite low due to incidence of pests and diseases, absence of efficient control measurements and limited availability and use of high quality seed, leading a significant yield gap (Weinberger and Msuya, 2004). Technical innovations can reduce yield gaps and increase the productivity of traditional vegetable crops. Improving agricultural productivity is crucial for improving the livelihood of farming communities in Tanzania as smallholders typically underutilize resources in their farming activities (Msuya, 2008). Some authors have argued for the adoption of new technologies designed to enhance farm output and income as a means to accelerate economic development (see for example, Schultz, 1964; Kuznets, 1966; Hayami and Ruttan, 1985). However, output growth is determined not only by technological innovations but also by the efficiency with which available technologies are used (Nishimizu and Page, 1982). The potential importance of efficiency as a means of fostering production has motivated a substantial number of research studies focusing on agriculture (Bravo-Ureta and Pinheiro, 1993).

In developing countries, agriculture and crop-level production efficiencies have been extensively investigated by measuring technical efficiency, economic efficiency and allocative efficiency (Ali and Choudhry, 1990; Parikh et al., 1995; Coelli and Battese, 1996). In sub-Saharan African, only a few studies have been conducted on technical efficiency, particularly for staple crops (Abdulai and Huffman, 2000; Duvel et al., 2003; Abdulai and Tietje, 2007; Asogwa et al., 2011). Of these studies, only Msuya and Ashimogo (2006) measured technical efficiency and its determinants for sugarcane farmers in Tanzania. Most studies analyzed the efficiency of production of major food crops, including maize, rice and wheat in farming systems where monocropping is the dominant cropping pattern with known crop-specific allocations of inputs such as land, labor and fertilizer. Based on a recent literature review, and to the best of our knowledge, no studies have measured technical efficiency for farmers who grow mostly traditional vegetables in Tanzania. The literature specified that in developing countries, farmers do not reach optimal levels of efficiency due to the inefficiency of resource allocation. Hence, the allocation of resources to improve production is important. The objective of our study was to measure the technical efficiency (TE) of farm households that grow traditional vegetables. Based on our objective, the following hypotheses were constructed and examined: (i) Farm output value significantly and positively increases with increase in inputs; (ii) A significant inverse relationship exists between farm size and TE. These hypotheses were tested with a Cobb-Douglas stochastic frontier production function. Farm size, for the purpose of this study, was grouped into four categories, namely marginal (0-1 ha), small (1-<2 ha), medium (2-<4 ha) and large farm holders (>4 ha) based on net operated area.

MATERIALS AND METHODS

A purposive sampling technique was used to select 181 farm households that primarily cultivate traditional vegetables in five administrative regions of Tanzania namely Arusha, Tanga, Morogoro, Dodoma and Dar es Salaam (Figure 1). A semi-structured questionnaire was used to survey the households between March 2013 and May 2013. Socioeconomic characteristics, land use, demographics, cropping patterns and inputs, and output data were collected during the cropping season, from March 2012 to February 2013.

Empirical model

Technical efficiency was measured using the Cobb-Douglas stochastic frontier production function. This approach was originated by Debreu (1951) and extended by Farrell (1957), Aigner et al. (1977) and Meeusen and Broeck (1977). The approach offers some advantages over other methods such as Data Envelopment Analysis, non-parametric approach, and non-frontier approach. Data Envelopment analysis is more appropriate for the industrial, rather than the agricultural sector. The non-parametric approach assumes that there is no fixed form for the frontier, which is a major disadvantage of the model (Ali and Byerlee, 1991). Compared to the non-frontier approach, the stochastic approach is easy to measure and interpret, consistent with most agricultural production efficiency studies, and captures a variation from the frontier due to random effect and technical inefficiencies (Ali and Byerlee, 1991; Duvel et al., 2003; Abdulai and Tietje, 2007; Asogwa et al., 2011; Rajendran, 2014). Technical efficiency is defined as the maximum output that can be produced from a specified set of inputs, given the existing technology available to the farmer (Koopmans, 1951). Therefore, use of resources is an important factor in the agriculture production process. Efficiency plays an important role in maximizing output with a given set of inputs and technologies, thereby resulting in increased income to the farmer.

Model specifications for stochastic frontier production function

We followed two types of econometric models in our study. First, we determined the effect of input use on output values of farm households using the Cobb-Douglas production function estimated using the ordinary least squares method. Second, we estimated the technical efficiency level of traditional vegetable farm households in Tanzania using the Cobb-Douglas stochastic frontier production (SFP) function. The parameters of stochastic frontier production functions model were estimated by using the maximum likelihood function, implemented in STATA version 11.0 econometric software.

The specification for SFP can be written as follows:

$$Ln\, Y_i = \beta_0 + \sum_{k=1}^{N} \beta_n \ln X_{ki} + D_i + v_i - u_i \qquad (1)$$

i = 1,.....N (Number of farm households), k = 1,.....N (Number of inputs); Ln is the natural logarithm with base *e*. Output Y: Y = value

Figure 1. Map of Tanzania showing study regions. Source: www.mapsofworld.com

of output of traditional vegetable crops per household (in Tanzanian Shilling currency i.e TZS) Inputs X: X_1 = Land: Net operated area per farm household. X_2 = Total cost of seed per farm (in TZS); X_3 = Total cost of manure per farm (in TZS); X_4 = Total cost of fertilizer per farm (in TZS); X_5 = Total cost of chemicals per farm (in TZS) X_6 = Total cost of irrigation per farm (in TZS) X_7 = Total cost of labor per farm (in TZS); X_8 = Total cost of machinery (tractor and other rented equipment per farm (in TZS); X_9 = Share of irrigated area.

Land represents total area of under irrigation and unirrigated land (in hectares), which explains farm size as well. It implies that the larger the farm size, the greater the opportunity to apply new technologies and have a better output value. The implication is that medium and large farms derive more gains from application of more capital than do small farms and also depend on possibility of large share of irrigated land to total land size. Therefore, Rajendran (2014) argued that the share of irrigated land area influences output value, particularly, the value of vegetable production and hence the inclusion of share of irrigated area as an independent variable in the estimation is required. Inputs such as cost of seeds, chemicals and inorganic fertilizer will significantly influence output values (Coelli and Battese, 1996). The dependent variable is a value of output of crops per household. The reason behind using output value rather than output by itself is that quality differences can be taken into account (Abdulai and Tietje, 2007). Taking account of production of all crops is more useful than single-crop production in the production function, because the single-crop production functions do not account for indirect production benefits (Sharma, 1992). The reason for including inputs as an independent variable is that farmers maximize their outputs from specified sets of inputs (seeds, chemical fertilizers, pesticides, manure and machinery) where each input has a significant influence on crop production (Coelli and Battese, 1996).

Table 1. Summary statistics of input costs (USD) and share of input costs (%).

Seed cost	Manure cost	Chemical fertilizer cost	Pesticide cost	Irrigation cost	Other cost	Labour cost	Total cost
14	58	84	95	75	48	93	467
3%	12%	18%	20%	16%	10%	20%	100%

Source: Primary Survey

RESULTS

A large share of the cost stream comes from the quantities of chemical fertilizers, pesticides and labor used (Table 1). The cost of family labor was imputed from the market wage for hired labor. It is possible that those chemical fertilizers are in short supply during peak seasons, which leads to higher prices in the open market. High labor cost could be attributed to labor migration from farm to non-farm activities, which creates labor shortages for on-farm activities and also takes away the most productive labor from farm production. Results from the stochastic frontier production analysis (Table 2) can be interpreted based on γ- parameters proposed by Battese and Corra (1977), who explained that the total variation of output from the frontier can be attributed to technical inefficiency and lies between zero and one. Further, Coelli (1996) argues that if $\gamma = 0$, it implies that the traditional average response function is an appropriate representation of the data, which can be consistently estimated by a Cobb-Douglas average production function via the ordinary least squares method.

To avoid the occurrence of multicollinearity in the regression estimations, this paper evaluated two models (model 1 and 2). In the first model, input costs of seeds, pesticides, manure, inorganic fertilizer, labour cost (including family labour) and net operated area were combined to avoid collinearity with share of irrigated land. In the second model, various input costs were treated independently along with share of irrigated land. However, the results show that in both models, estimates of the γ-parameter are 0.91 and 0.86 for the Cobb-Douglas stochastic frontier production models on normal distribution, respectively. Furthermore, the likelihood ratio (LR) test results were estimated at 18.93 for model 1 and 13.91 for model 2, both of which are significant at the 5 and 1% probability levels. The significant level indicates that the technical inefficiency effects are a significant component of the total variability of total crop output in the study area, and hence inefficiency effects are a stochastic process. In sum, the hypothesis tested proved the presence of inefficiency and stochastic process in the frontier model.

The parameters of the stochastic frontier production function were estimated using the maximum likelihood approach assuming a half-normal distribution, while parameters of the average Cobb-Douglas production functions (Table 2) were estimated by the ordinary least squares approach (Table 3). The similarities of the slope parameters across equations confirm that the frontier function represents a neutral upward shift of the average production function.

Coelli and Battese (1996) argue that the parameters of estimates of the stochastic production frontier model need to be discussed in terms of output elasticities evaluated at the mean values with respect to the various inputs. We evaluated our results for the two models based on estimates of parameters obtained with the average Cobb-Douglas production function (Table 3), which reports the elasticities of mean value of output for various inputs used in farming activities. The results show that the coefficients are of coefficients are of the expected signs and most of them are statistically significant.

DISCUSSION

The elasticity of mean value of farm output for seed turns out to be insignificant in model 1, but after excluding net operated area in model 2, coefficient of seed cost became significant in model 2. This implies that the cost of seed is an important factor for farmers to increase their value of output. Although seed prices have a significant impact on output value, the value of the coefficient is lower than the coefficient of other inputs after excluding net operated area. Price may not be sensitive to farmers to increase their output value, as they mostly used own-saved seeds (Rohrbach et al., 2003; Afari-Sefa et al., 2013). Interestingly, the elasticity for fertilizer, labor and share of irrigated area under cultivation is higher compared to other inputs (chemicals, manure and seeds).

A test of equality among coefficients was conducted (Table 3). The null hypothesis was accepted through test of equality in models 1 and 2, hence the constant returns to scale is observed. The observance of a constant return-to-scale implies an increase in value of output per unit increase in input, suggesting that farmers are not using their resources efficiently. This means that farmers can still increase their level of output at the current level of resource allocation, and that production efficiency among farmers would result in higher farm output in the study area. Policies that encourage technical efficiency among farmers would bring about an

Table 2. Results of Cobb-Douglas stochastic frontier production function based on normal distribution.

Dependent variable: Ln (value of farm output)	Model 1 Model 2	Model 2
Independent variables:		
Ln values		
Ln seed cost	0.009	0.023*
Ln pesticides cost	-0.005	0.001
Ln manure cost	0.166***	0.230***
Ln inorganic fertilizer cost	0.296***	0.295***
Ln labor cost (includes family labor cost)	0.344***	0.322***
Share of irrigated area		0.233*
Ln net operated area	0.129	
_constant	4.395***	3.788***
Insig2v		
_cons	-2.630***	-2.336***
Insig2u		
_cons	-0.355	-0.502**
Statistics		
N (Number of observation)	181	181
sigma_v	0.268	0.311
sigma_u	0.837	0.778
sigma2	0.773	0.702
lambda	3.119	2.502
$\gamma=(\sigma\_u^2)/\sigma^2$	0.91	0.86
Likelihood-ratio test of sigma_u=0: chibar2(01)	18.93**	13.91***
Test of hypotheses		
The inefficiency effects are not present H0: $\gamma = \beta 0 = \ldots = \beta n = 0$	Null rejected	Null rejected
Decision	Presence of inefficiency proceed for TE through frontier estimates	Presence of inefficiency proceed for TE through frontier estimates
The inefficiency effects are not stochastic H0: $\gamma=0$ (Based on Chibar2 stat)	Null rejected	Null rejected
Decision	Inefficiency effects are stochastic	Inefficiency effects are stochastic

Significant level: *** p<.01; ** p<.05; * p<.10; γ parameter is used to test whether the technical inefficiency affects output or not. Source: Authors' calculation

increase in farm output in the study area; therefore, it is necessary to understand the level of technical efficiencies by regions and farm size.

Technical efficiencies

The estimated mean value of the technical efficiency of the farm households studied is reported in Tables 4 and 5 by regions and farm size, respectively. These predictions are derived from the estimated model 2 (Table 2). The estimated mean technical efficiencies differ slightly across regions and farm size. Overall, the estimated mean technical efficiency is 0.67 (Table 4). Several reasons may account for the observed variation in technical efficiencies from the regions studied. Huang and Bagi (1984) note that these differences may be due to different approaches

Table 3. Cobb-Douglas production function (ordinary least squares).

Variable	Model 1	Model 2
Overall		
Ln of seed cost	0.036	0.042***
Ln pesticides cost	0.002	0.007
Ln of manure cost	0.209***	0.258***
Ln of inorganic fertilizer cost	0.405***	0.354***
Ln labour cost (including family labour)	0.331***	0.302***
Share of Irrigated area to total operated area		0.335***
Ln of net operated area	0.050	
Constant	2.282***	2.330***
N	181	181
r2	0.84	0.85
r2_a	0.84	0.84
Test of equality - constant returns to scale (CRS)		
∑βi	1.03	1.30
F-Stat	0.32	0.22
Prob > F	0.5741	0.234
H0: Null Hypothesis (∑βi = 1)	Accepted null	Accepted null
Returns to scale	Constant return to scale	Constant return to scale

Source: Authors' calcuation

Table 4. Mean level of technical efficiency by regions.

Regions	Mean	p50	sd	Min	Max	N	Equal variance t-test*
Dodoma	0.60	0.69	0.25	0.06	0.92	57	
Arusha	0.79	0.75	0.13	0.29	0.94	57	0.0101**
Tanga	0.72	0.74	0.15	0.19	0.91	20	0.0125**
Morogoro	0.70	0.75	0.13	0.27	0.91	25	0.032**
Dar	0.54	0.66	0.17	0.02	0.84	22	0.052**

Significant level: *** p<0.01; ** p<0.05; * p<0.10 (Base Dodoma region). Source: Authors' calcuation

Table 5. Mean level of technical efficiency by farm size.

Farm size	Mean	p50	sd	Min	Max	N	Equal variance t-test*
Small farm (0-2	0.66	0.73	0.21	0.06	0.92	139	0.0162**
Middle farm (2ab	0.69	0.73	0.13	0.4	0.86	32	0.0321**
Large farm (4ha	0.74	0.76	0.09	0.58	0.91	10	
Total	0.67	0.73	0.2	0.06	0.92	200	

Significant level: *** *p*<0.01; ** *p*<0.05; * *p*<.10 (Base large farm). Source: Authors' calcuation

employed. Specific attributes of each location (agroclimatic and soil variables, access to markets, extension services, etc.) play a role in technical efficiencies (Battese and Coelli, 1988). Coelli et al. (1998) indicate that over-estimates of technical efficiency might also be related to the higher number of input-output variables. Technical efficiency depends on the assumed distributional form of the one-sided error in the functional form (Haji, 2006). Finally, the difference may be due to the type of crops and cultivation method (Bagi, 1982).

The computed mean of technical efficiency (Table 5) shows insignificant differences between small, medium and large farms. However, it indicates that large farms are more efficient than small or medium farms. The literature points to a similar situation in the agrarian sector of other developing countries (Huang and Bagi, 1984), with variations from crop to crop. Based on the computed mean technical efficiency, the results indicate that the Arusha region is technically more efficient in agricultural resource use than the other four study regions in the study. The observed differences is attributed to the fact that, the Arusha region falls under the Northern Highlands agroclimatic zone and experiences bimodal rainfall of 760-1200 mm per annum (usually from October- December and March-May). Therefore, farmers obtain good precipitation for vegetable cultivation.

In Tanzania, the major possible reasons for the observed regional differences include agroclimatic variability, access to extension services, and infrastructure facilities. The test for equality of technical efficiency indicated that there were statistically significant differences in the technical efficiency across farm size, with larger landholdings having higher observed values than smallholdings. It indicates that other than the use of machinery, large-scale farmers put in more material inputs than small-scale farmers, which results in increased productivity. Therefore, medium and large farms gain more by the application of more capital compared to smallholdings. This may be because smallholders cannot make use of improved or better inputs due to limited land area and other constraints.

Conclusion

Overall, the efficiency level pattern across farm size increases with increasing farm size, which implies that large farms are technically more efficient than small and medium farms. This rejects our null hypothesis that technical efficiency is inversely related with the farm size. The mean technical efficiency is directly related to farm size. Individual technical efficiencies indicate that most of the farmers used their resources inefficiently in the production process, and were not obtaining maximum output from their inputs.

Opportunities thus exist for improving current technical efficiency levels. Technical efficiency among farm households could be increased by 33% (that is, maximum TE *minus* mean TE). This would enable farmers to obtain maximum output from their given quantum of inputs, and increase their farm incomes, thereby reducing poverty (Asogwa et al., 2011). However, the mean of TEs indicates that if the average farmer of the sample could achieve the TE level of his most efficient counterpart, then average farmers of the sample could increase their output by 27% approximately through better use of available production resources given the current state of technology (that is, 1-(0.67/0.92)*100).

There is considerable room to increase agricultural output where farmers cultivate vegetables without additional inputs, given the existing technology in the regions studied. Identification of farm-specific factors contributing to technical inefficiencies is very useful and important for policy formation. Because farm size is directly related to technical efficiency, there is a need to enhance existing cluster farming practices and strengthen farmers' associations among smallholders to encourage knowledge sharing and thus improve technical efficiency. Vegetable cultivation is a labor-intensive, year-round activity. To attract more people to engage in farm labor, it is necessary to have better incentives such as competitive pay packages based on market prices, or by linking national employment programmes with farming activities in the study region. There is a need to improve farm management skills in all the regions studied to promote efficient use of resources and increase economic development.

Conflict of Interest

The authors have not declared any conflict of interest.

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A decision framework for resource poor smallholder farmers on maize production based on results from empirical studies in the coastal lowlands of Kenya

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Maize is a principal food crop in Kenya and the coastal lowlands. Choice of the enterprise at household level is influenced by the social position maize commands both as a staple food and trade facility or good while production patterns are dictated by various factors among them being resource endowment. Research in the recent past has provided technological recommendations that include fertilizer and pesticides use along with yield data with different management regimes. In the event of not using fertilizer or pesticides, yield losses of 0.421 and 0.203 by proportion of the yield potential were recorded in two different empirical studies respectively for the improved varieties thereby translating to a total gross margin short-fall of KES. 11,192/= per hectare. The household economic effect of this loss therefore doubles to wastage of land space and on the overall denied economic returns to labor devoted to the enterprise. The findings give evidence to recommend devotion to hard decisions on enterprise choice in place of maize especially where land is a limiting factor. High value short duration crops or a balanced cropping mix are thus recommended as best bet alternatives.

Key words: Maize, yield losses, field pests, fertilizer, coastal lowland, gross margin, resource poor and household.

INTRODUCTION

Maize (*Zea mays*) is an important staple food crop for most households in Kenya and the main source of income and employment for the majority of rural households (Kirimi et al., 2011). Food security and welfare of farming population are dependent on the productive capacity of the maize farmers (Liverpool-Tasie et al., 2011). More than 70% of the maize area in Kenya is cultivated by small holders whose maize acreage is below 20 acres (Karanja, 1990). Maize is also the most important food crop at the coast particularly in Kwale (Kega et al., 1994) and in Kilifi (Otieno et al., 1994) of the coastal Kenya region which account for half of all maize produced in the region. As the main staple food crop, maize is grown across all the agro-ecological zones in the region even where land is suitable for livestock and millets (Wekesa et al., 2003).

Maize yield potential is influenced by rainfall regime and soil nutrient levels. The coastal lowlands are known to be comprised of diverse ecological potential ranging from the coastal lowland (CL) 2 to 6 within which rainfall

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regimes and significantly varying soil types and nutrient levels (Wekesa et al., 2003). Maize is grown across all these CLs hence this ecological spatial stretch justifies the social and economic significance of the enterprise to the farm households and its overall implication if there is total failure due to any eventualities. Other ecological challenges that influence maize performance include management regimes based on moisture and nutrient availability as well as prevention of field losses emerging from pests and diseases (Morris et al., 1999). Efforts to address water stress, nutrient needs, pest and disease resistance in maize have been done through collaborative work between the Kenya Agricultural Research Institute (KARI) and the Maize and Wheat Improvement Centre (CIMMYT) through the Insect Resistant Maize for Africa (IRMA), Nitrogen Use Efficiency (NUE), Water Efficient Maize for Africa (WEMA) and the Drought Tolerant Maize for Africa (DTMA) programs and some progress has been attained. Different studies have also been conducted on response of maize to different management regimes such as those for fertilizer (with or without) by Muli et al. (1998) and yield performances. A number of farm households still prefer local maize varieties for diverse reasons including taste superiority and the long experience they have in growing these varieties (Odendo et al., 2001). Even with the preference for the local maize cultivars, De Groote et al. (2005) observed an increasing adoption in improved maize seed which as a result improved per unit area grain yield under recommended management regimes. For the potential of all maize varieties to be realized, optimal application of inputs such as fertilizer and pesticides is a necessity which requires the farm households' purchasing power. Pender, (2008) linked the inability to access among other factors basic agricultural inputs to poverty.

In the coastal lowland Kenya, unavailability of the improved seed due to poor spatial spread of agro-dealers also complements use of local seed. Further and more critical, the coastal small holder farm households live in a resource poor framework which limits them to access important inputs such as improved seed, fertilizer and pesticides (Wekesa et al., 2003). It is therefore from the recognition of the farm households' resource framework (including land parcel or size holding) that an economic evaluation of the maize enterprise returns was done after accounting for all the eminent losses (from lack of fertilizer and pesticides use) in order to provide a decision framework on the best bet alternatives to the maize enterprise.

LITERATURE REVIEW AND ECONOMETRIC FRAMEWORK

This study was borne from advances made from on-farm work involving small holder maize farmers in maize production under different management resource regimes that included fertilizer use and protection from field pests. An econometric framework was then generated where maize yield potentials were used alongside and input management regimes (use or no use) as sources of variation on yields (variance components comparison). The suggested model can then be used to estimate expected yield gaps or economic losses that small holder farmers need to accommodate in the absence of applying recommendations. De Groote (2005) estimated yield losses from the stem borers (field pests) using an iterative approach where he estimated yield loss as difference between potential (Yp) and actual yield (Yr) and then expressing the difference as a proportion of potential yield, hence;

$$r=\frac{Yp-Yr}{Yp} \quad (1)$$

This loss follows lack of control of field pests and similarly, it is also possible to estimate the yield loss in the event of not using fertilizer as:

$$n=\frac{Yp-Yn}{Yn} \quad (2)$$

Where Yn is the actual yield when no fertilizer is used and n is the proportion of yield lost when no fertilizer is used.

Under normal farm conditions, the effects of not using fertilizer nor controlling field pests occur concurrently and is therefore postulated that the economic loss is a summation of the two and can therefore be summarized as (Plessis, 2003):

$$Ytl=\Sigma\left(\frac{Yp-Yr}{Yn}, \frac{Yp-Yn}{Yp}\right) \quad (3)$$

Where Ytl is the overall proportion of yield loss from not field pests and not using recommended fertilizer which can be expressed as:

$$Ytl= \Sigma(r,n) \quad (4)$$

$$Ytl= r + n \quad (5)$$

Hence for the decision framework to be functional, two empirical studies by Hugo De Groote (2005) and Muli et al. (1998) were used alongside current maize farm-gate market price (P) (2013/2014) of KES. 30/= per kg. This therefore implies that the farm household economic loss (El) expressed as a proportion of the potential yield will be;

$$El=P^*(r + n) \quad (6)$$

Table 1. Extent of grain losses (in metric tons) from field pests per hectare by agro-ecological zone in Kenya

Agro-ecological zone	Grain yield/loss parameter				
	Yield (t/ha)	Production '000 tons	Loss '000 tons	% loss of potential	Loss (t/ha)
Lowland tropics	1.29	53	14	20.3	0.346
Dry mid-altitudes	0.98	162	28	14.6	0.175
Dry Transitional	1.15	76	20	20.7	0.315
Moist transitional	2.65	1234	173	12.3	0.386
Highlands	2.88	909	100	9.9	0.320
Moist mid-altitude	1.34	231	60	20.7	0.374

Adapted from De Groote (2005).

Table 2. Results from an empirical study of maize under fertilized and unfertilized conditions.

Treatment/parameter	Variety actual/realized yields (in t/ha)			
	PH4	PH1	CCM	Local
Fertilized	4.2	3.2	3.2	2.8
Unfertilized	2.3	2.0	1.8	1.6
Yield gap/loss	1.9	1.2	1.4	1.2
Proportion of loss to yield under fertilized condition	0.452	0.375	0.438	0.429

Adapted from Muli et al. (1998).

and the money value of the salvaged yield will be;

$$Syv = 1 - P^*(r + n) \quad (7)$$

for *Syv*=value of salvaged yield.

MATERIALS AND METHODS

The study is based on on-farm work done in the coastal lowlands in Kwale and Kilifi Counties (Makambani, Mtepeni and Goshi) by De Groote, (2005) and Muli et al. (2008) in separate studies for assessing and estimating maize yield losses from field pests and no fertilizer use respectively but using the same maize variety based incomplete block design where ten farms were used in each of the three clusters (Makambani, Mtepeni and Goshi) and four maize varieties namely Pwani 1 (PH1), Pwani 4 (PH4), Coast Composite Maize (CCM) and local were evaluated.

The three sites are all located within the coastal lowland tropics and represented an average agro-ecological potential ranging from the coastal lowland zone three (CL3) through to CL4/5 and a soil type variation characteristic of the coastal lowland tropics as described by Hassan (1998). For the purpose of this study and with the increasing adoption of improved maize varieties (PH1, PH4 and CCM) yield losses results from field pests (De Groote et al., 2005) were used along with the results by Muli et al. (1998) under fertilization and no-fertilization maize production to estimate the total loss as a common option to some households that are either resource constrained or simply do not follow recommendations due to other reasons. The underlying assumption is that the impacts of the farm households' resource framework and underlying decisions are recursive and sequential from plant vigor build-up to yield performance (Schepers and Holland, 2012).

The results on the respective studies on grain loss from field pests and loss from lack of fertilizer use are summarized in Tables 1 and 2. Hence, for the purpose of accounting for the economic impact from field pests and lack of fertilizer use for the maize enterprise of in the region (coastal lowland Kenya), a simple valuation technique using maize grain average market prices stated at Kenya Shillings (KES) 30/= per kg during the year 2010 to 2014 period.

RESULTS

From De Groote (2002) work the proportion of grain loss from field pests (mainly the stem-borer) in the coastal lowland tropics was demonstrated as 0.23 of the potential while Muli et al. (1998) documented a loss proportion from lack of fertilizing maize at 0.421 (on average across all varieties).

This according to the summation model in formula "iii" above adds to a total loss by proportion of 0.624 to the potential yield under controlled conditions (fertilization and field pest control). Further, by using the formula "vi" the economic losses from both scenarios (no fertilizer and no pesticides for field pests) the estimated economic with the application of current grain maize market prices (of KES. 30/= per kg) and using a mean yield potential for the three improved varieties (PH4, PH1 and CCM) of 3.5 tons/ha, the yield loss was estimated at 2.2 tons with a value of KES. 66,000/= per ha.

DISCUSSION

The unchecked losses due to lack of fertilizer use and control of field pests empirically demonstrated that resource poor households stand to endure heavy economic losses from growing maize, The economic value of salvaged proportion stands at only 37.6% of the potential yield under recommended management thereby implying an economic loss of which losses KES. 39,000/= per ha. This is double loss considering the substitution effect of both land use and labor (Regier et al., 2013) in a dynamic agricultural environment supported by market forces of demand and supply. Using a simple gross margin (GM) analysis (which essentially is the total revenue less variable costs).

Muli et al. (1998) documented a shortfall by proportion of 0.342 per hectare for improved varieties following lack of fertilizer and control of field pests. This short-fall is one which arises from the 0.421 proportion of grain yield from unfertilized maize production system to the potential. Hence by using a similar model which sums the yield losses from unfertilized production system and that where no field pests are controlled (0.203), the total GM short-fall is estimated at about KES. 11,192/= per hectare. The GM short-fall estimation provides an explicit picture of the unattained economic return of the maize enterprise given a scenario where farmers do not practice the agronomic recommendations due to the basal income bracket that groups them in the resource poor platform of farmers (Muli et al., 1998). This paper provides the resource poor farm households with an opportunity at their disposal to choose to grow maize under lack of the recommended package as they prepare to face the aforementioned losses or otherwise.

CONCLUSION AND RECOMMENDATIONS

The estimated aggregate loss proportion emanating from the low input maize production practice (no fertilizer nor pesticide used) clearly demonstrates the economic loss that resource poor farmers undergo or are likely to undergo. The effect of this is a double loss from wasted land due to poor enterprise allocation decisions and wasted labor that in the short or long run is not effectively compensated for (Regier et al., 2013). This paper therefore tries to provide empirical evidence and a decision framework for which farmers and stakeholders in the maize enterprise can use to make hard production decisions despite the position of the maize crop in the farming systems and at household level and the fact that there is a notable out-migration from the high potential to low potential areas due to various reasons including population pressure among other reasons (Karanja and Renkov, 2002).

The paper recommends enhanced efforts to develop early maturing and high yielding maize varieties or a balanced cropping mix particularly to farm households with an average land holding of above one acre and an alternate cropping system for those households with less than one acre land holding. A second and alternate recommendation is for resource poor farm households to shift to short-duration high value crops whose demand and return value can support inputs' purchase and use. Vegetables such as okra, capsicum, tomatoes, brinjals and spinach are such enterprises recommended for quick and higher returns (Owuor, 2002).

This is a significant shift as that reported by Wachira (2012) on the shift from growing of tree cash crops such as tea and coffee to tomatoes under green house production systems. Wachira (2012) also attributes choice of an enterprise or production system as a consideration of various factors including, costs, returns, and availability of information among others which should be the case with the resource poor famers in the coastal lowlands of Kenya.

Conflict of Interest

The authors have not declared any conflict of interest

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Factors determining allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia

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This study was conducted in Northern Ethiopia, Adwa district. The main objective of the study was to examine factors influencing allocation of land for improved wheat variety by smallholder farmers of the study area. Descriptive, inferential and econometric methods were used to analyze data. Results of descriptive and inferential analyses showed that; adopters had high family size in adult-equivalent, high number of tropical livestock unit, large land size, high frequency of extension contact, access to credit service, they were followed formal schooling, and they were nearest to main road and market as compared to non-adopters. Tobit model was used to analyze factors influencing adoption of improved wheat technology econometrically. A total of thirteen explanatory variables were included in the model. From the tested variables only eight variables (education level of household head, family size, tropical livestock unit, distance from main road and nearest market, access to credit service, extension contact and perception of household towards cost of the technology) were found to be the significant factors affecting adoption of improved wheat variety. Implication of results of this study is that any development intervention through improved wheat technologies should consider the aforementioned socioeconomic characteristics and determinants of adoption for success.

Key words: Adoption of Improved wheat variety, Adwa, smallholder farmers, Topit model.

INTRODUCTION

Agriculture is the mainstay of the Ethiopian economy. It employs 80% of the population and contributes about 41% of GDP and 86% of exports (Bingxin et al., 2011). Besides its contribution as the main income-generating sector for the majority of the rural population, it serves as the main source of household food consumption (Samia, 2002).

The agricultural sector in Ethiopia is dominated by subsistence, low input, low output and rain-fed farming system. The use of improved seeds is quite limited despite government efforts to encourage the adoption of modern agricultural system and intensive agricultural

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practices. Therefore, improving the productivity, profitability, and sustainability of smallholder farming is the main pathway out of poverty in using agriculture for development (World Bank, 2008). One important way to increase agricultural productivity is through the introduction of improved agricultural technologies and management systems. Adoption of new agricultural technology such as high yielding varieties stimulates the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy (World Bank, 2008).

Cereals dominate Ethiopian agriculture; accounting for about 70% of agricultural GDP. Wheat is one of the major cereal crops grown in Ethiopia (Hailu, 2003). It is grown by smallholder farmers in the highlands and mid highland areas of the country (Bingxin et al., 2011). The productivity of the crop has been low and a number of yield improving technologies like seeds of improved varieties have been recommended for use by wheat producing smallholder farmers in the country. However, the level of adoption of the technologies is not as expected. Farmers of the study area faces problem of low productivity of the crop due to use of traditional method of farming system and use of low productive inputs.

Studies conducted in Yelmana Densa and Farta Districts of Northwestern Ethiopia (Tesfaye et al., 2001) indicate that socioeconomic, institutional and technical factors are accountable for determining technology adoption. However, these recommendations are location specific and would justify the need for research elsewhere. It is expected that geographical and climatic differences would affect the adoption decision of farmers and studies done elsewhere may not be of direct relevance to address the problems and opportunities of the present study area. Therefore it is relevant to examine the specific factors that affect the adoption of improved wheat variety by farmers of study area. This information is expected to make easy the distribution of the improved wheat technologies in the study area and suggest interventions that may help improve the efficiency of agricultural research and extension in promoting smallholder, climate risk-prone agriculture in wheat production.

The main objective of this study was to analyze factors affecting allocation of land for improved wheat variety by smallholder farmers of the study area.

METHODOLOGY

Description of the study area

This study was conducted in Northern Ethiopia, rural Adwa district. Adwa is found about 1006 kilometers from Addis Ababa and 223 kilometers away from Mekelle. The district has total area coverage of 66,618 ha of which 13,714 ha is cultivated land. The geographical structure of the district is both low land and semi-low land. About 32.2 and 67.8% of the cultivated land is found in the low land and semi-low land respectively. The district has a total household of 24,692 and has a total population of 108,647, out of which 54,659 were females and the rest of 53,988 were males. The average temperature of the area is 27°C and average annual rainfall ranges from 600 to 850 mm. The main economic activity of the study area includes both crop and livestock production. Some of the major crops grown in the area include teff, wheat, barley, finger millet, sorghum and maize and the major livestock production includes cattle, sheep, goat, donkey and poultry.

Data collection

The study uses both primary and secondary sources of data. The primary data was collected through individual interviews of the selected respondents whereas the secondary data was gathered from annual and monthly report of district agriculture Office and reports from the center statistical agency. During sampling process two-stage sampling procedure was used to select sample farmers that were included in the study. In the first stage, out of the total 18 *peasant associations* of the district four *peasant associations* were selected purposively based on their wheat production performance. In the second stage, from the selected *peasant associations,* 160 respondents were identified based on probability proportional to size of households of each *peasant associations* and the subsequent application of random sampling technique. After the sampling process was completed data were collected by using formal and informal survey methods of data collection.

Data analysis

In this study both descriptive statistics and econometric models were utilized to assess the relationship between explanatory and dependent variables. Descriptive statistics involving mean, percentage and standard deviations was used to assess the socio-economic characteristics of the sample households and farmer's response for adoption of improved wheat technologies and the type and distribution of improved wheat variety among the farmers of the study area. Also, t-test and χ^2-test were employed to assess the relationship among the variables of interest. For the econometrics model Tobit model was used to analyze factors affecting the farmer's decision to allocate land for improved wheat variety and the intensity of adoption by farmers. In Tobit model, decisions whether to adopt or not and how much to adopt are assumed to be made jointly and hence the factors affecting the two level decisions were taken simultaneously (Solomon et al., 2010). As stated in Gujarati (2004) the Tobit model to estimate the factor affecting the adoption was defined as:

$$\begin{cases} y_i = y^* = X_i\beta + u_i & \text{if} \quad y_i^* > 0 \quad u_i \approx n(0, \sigma^2) \\ y_i = 0 & \text{otherwise} \end{cases} \tag{1}$$

Where: y_i = land size allocated for improved wheat variety at a given level of *Xi*; y^* = unobserved latent variable, n = number of observations; *Xi* = vector of explanatory variables; β = vector of unknown coefficients (parameter to be estimated); and U_i = independently and normally distributed error term with zero mean and constant variance σ^2.

The model parameter was estimated by maximizing the Tobit likelihood function of the following:

$$L = \prod_{Y_i^* > 0} \frac{1}{\sigma} f\left(\frac{Y_i - \beta_i X_i}{\sigma}\right) \prod_{Y_i^* \le 0} F\left(\frac{-\beta_i X_i}{\sigma}\right) \tag{2}$$

Where; f and F are respectively, the density function and

Table 1. Description of independent variables.

Variables	Nature of the variable	Unit of measurement	Expected sign
Age of household head	Continuous	Years	+
Education level of household heads	Continuous	Year of formal schooling	+
Sex of household head	Dummy	Male/female	Male adopt more than female
Sizes of land holding of household	Continuous	Hectare	+
Frequency of contact with extension agents	Continuous	Number of visit farmer's land by development agents per month	+
Access to credit facility	Dummy	Yes/Not	+
Distance from market	Continuous	Kilometer	-
Distance to the main road	Continuous	Kilometer	-
Family size in adult-equivalent	Continuous	Number of adult-equivalent	+
Livestock holding (TLU):	Continuous	Number of TLU	+
Perception of farmers about cost of technology	Dummy	Ordinal variable	-
Perception of farmers about yield of improved wheat technologies	Dummy	Ordinal variable	+
Participation of the household head in leadership position	Dummy	Yes/no	+

cumulative distribution function (Maddala, 2005).

The marginal effect of an explanatory variable on the expected value (mean proportion) of the dependent variable was estimate by:

$$\frac{\partial E(Y_i)}{\partial Xi} = F(z)\beta_i \quad (3)$$

Where z is defined by:

$$\frac{\beta ixi}{\sigma}$$

The change in the probability of adopting improved wheat technology as independent variable X_i changes was estimate by:

$$\frac{\partial F(z)}{\partial X_i} = f(z)\frac{\beta_i}{\sigma} \quad (4)$$

Where, $z = X\frac{\beta}{\sigma}$, F (z) is the cumulative distribution function, f (z) is the value of derivative of the normal curve at a given point, z is the Z-score for the area under normal curve, ß is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error terms. Similarly, the change in intensity of adoption with respect to change in an explanatory variable among adopters was estimated by:

$$\frac{\partial E(Y|Y_i^* > 0)}{\partial X_i} = \beta\left[1 - z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right] \quad (5)$$

In this study the dependent variable was the land size allocated for the production of improved wheat varieties. Whereas the independent variables that were expected to affect the dependent variable with their unit of measurement and expected sign are presented in Table 1.

RESULTS AND DISCUSSION

Socio-economic characteristics of sample households

The descriptive statistics of some selected socio-economic characteristics of sample farmers examined in this study are presented in Tables 2 and 3. Table 2 presents for continuous variables whereas Table 3 presents for dummy variable. Out of the total sample respondents 118 were adopters and 42 were non-adopters.

Table 2 shows the result of descriptive statistics for continuous variables. As shown from the table, t-value was computed for all continuous variables and it was found to be statistically significant for family size in adult equivalent, education level, TLU, Average extension contact per month and farm size at 1% level of significance. This implies that there was significant difference in all these variables between the two categories (adopters and non-adopters).

Table 3 shows the result of descriptive statistics for dummy variables. The chi-square test was computed for the dummy variables and it was found to be statistically significant for credit access, Perception of farmers towards yield and cost of the variety at significance level

Table 2. Descriptive statistics of some selected continuous variables.

Variables	Adopters		Non adopters		Total		t-value
	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	
Age	48.89	9.93	47.45	11.66	48.51	10.40	0.769(NS)
Family size in adult equivalent	3.89	0.99	2.54	0.63	3.54	1.09	8.282***
Education level of household head in year	2.96	2.59	1.4	2.64	2.29	2.64	5.937***
Farm experience in year	26.5	10.69	24.7	12.9	26	11.29	0.883(NS)
TLU	4.44	0.64	3.21	0.48	4.13	0.81	11.453***
Average extension contact per month	2.5	0.95	1	0.74	2	1.18	10.669***
Land holding	0.71	0.3	0.52	0.17	0.65	0.30	5.53***

Source; Own computed result, 2011. ***, Significant at 1%; **, significant at 5%; NS, not significant.

Table 3. Descriptive statistics of some selected dummy variables.

Variables		Adopters		Non adopters		Total		χ^2
Sex		No.	%	No.	%	No.	%	
Sex	Male	96	81.4	35	83.3	131	81.9	4.738(NS)
	Female	22	18.6	7	16.7	29	18.1	
Participation in leader ship activity	Yes	50	42.37	15	35.71	65	40.63	5.134(NS)
	No	68	57.63	27	64.29	95	59.37	
Access to credit service	Yes	110	93.2	9	2.38	119	74.38	12.79***
	No	8	6.8	33	97.62	41	25.62	
Perception towards yield	Low	1	0.8	2	4.8	3	1.9	34.435***
	Medium	15	12.7	22	52.4	37	23.1	
	High	102	86.4	18	42.9	120	75	
Perception towards cost	Cheap	30	25.4	-	-	30	18.8	16.93***
	Medium	46	39	-	-	46	28.8	
	Expensive	42	35.6	42	100	84	52.4	

Source; Own computational result, 2011; NS, Not significant; ***, significant at 1%.

Table 4. Category of respondents based on type of improved wheat Varieties used and total land allocated for improved wheat.

Description	Number of respondents	%
Variety type		
HAR1685	79	66.95
HAR1686	32	27.12
HAR2501	7	5.93
Total	118	100.0
Land size in hectare		
<0.25	76	64.4
0.25	39	33.1
>0.25	3	2.5

Sources: Own computational result, 2011.

of 1%. This indicated that there was systematic difference in these variables between the two categories.

Category of respondents based on type of improved seed they used and allocation of land for improved seed

The types of improved wheat varieties distributed to farmers of the study area were HAR1685, HAR2501 and HAR 1686. From Table 4; out of the total adopters 79(66.95%) of them were user of HAR1685, 32 (27.12%) were used HAR1686 and the remaining 7 (5.93%) were user of the variety type of HAR2501. Since most farmers of the study area had problem of land shortage; the proportion of land allocated for improved variety was very small. From Table 4, 64.4% of adopters allocated less than 0.25 ha, 33.1% of them allocated 0.25 ha and 2.5% of them allocated greater than 0.25 ha of land to the improved wheat variety.

Table 5. Maximum likelihood estimates of Tobit model of adoption of improved wheat variety.

Land	Coefficient	Robust Std. Err.	t-Value
Sex of house hold head	0.087	0.008	1.13
Educational level of household head	0.064	0.001	5.22***
Participation of HH head in leadership activity	0.065	0.006	1.12
Farming experience in year	1.94e-06	0.000	0.01
Family size in adult-equivalent	0.128	0.005	2.65***
Sizes of land holding of HH	0.132	0.012	1.13
Distance to main road	-0.082	0.003	-2.64***
TLU	0.304	0.007	4.42***
Access to credit facility	0.563	0.011	4.90***
Frequency of contact with extension agents/month	0.012	0.004	3.38***
Perception of HH about yield of the variety	0.012	0.009	1.34
Perception of HH about cost of the technology	-0.015	0.005	-3.07***
Distance from market	-0.033	0.002	-2.44**
CONSTANT	-0.108	0.044	-2.45**
Numbers considered	160		
Log likelihood function	226.81403		
Lift censored	0		
Right censored	+infinity		

Source: Computed from the field survey data 2011; TLU, Tropical Livestock Unit, HH, household. ***,** significant at 1 and 5% respectively.

Table 6. Marginal effect of explanatory variables on use of improved wheat variety.

Variable	Change in probabilities as independent variable changes $\frac{\partial F(z)}{\partial X_i}$	Change among entire sample $\frac{\partial E(Y_i)}{\partial Xi}$	Change among adopters $\frac{\partial E(Y \mid Y_i^* > 0)}{\partial X_i}$
Educational level of household head	0.117	0.051	0.049
Family size in adult equivalent	0.023	0.13	0.098
Distance from main road market	-0.015	-0.064	-0.063
TLU	0.056	0.025	0.021
Access to credit facility	0.103	0.513	0.425
Frequency of contact with extension agents/month	0.022	0.126	0.092
Perception of HH about cost technology	-0.027	-0.014	-0.012
Distance from market	-0.060	-0.028	-0.025

Source: Computed from the field survey data 2011; TLU, Tropical livestock unit; HH, household.

Determinants of adoption of improved wheat variety

It is well known that adoption of improved technologies depends on different socio-economic, demographic and institutional factors. Different variables are important across different space and time in explaining adoption of new technologies. For this study thirteen (5 discrete and 8 continuous) variables were hypothesized to influence the adoption of improved wheat variety in the study area. Among these, eight of the explanatory variables were found to be statistically significant in explaining the status and intensity of adoption of improved wheat technology in the study area. The estimated results of the Tobit model in Tables 5 and 6 showed that the significant variables affecting use of improved wheat variety in the study area include; educational level of household head, family size in adult-equivalent, distance to main road, tropical livestock units, access to credit facility, frequency of contact with extension agents, perception of household towards cost of the technology and distance from the nearest market.

Educational level of household head

As expected educational level of household head was affected the adoption decision of farmer of the study area positively and significantly at less than one percent significance level (Table 5). This result is similar with studies by Nzomoi et al. (2007) education of household head affects positively and significantly adoptions of production of horticultural export produce. Also the studies by Ozor and Madukwe (2005), Motuma et al. (2010) and Isaiah et al. (2007) confirmed similar results. Results of analysis of marginal effect show that an increase in the level of education by one year increases the probability of being an adopter by 11.7% and it increases the level of adoption by 0.049 and by 0.051 among the adopters and the total sample in that order (Table 6). This implies that having high formal year of education increases the level of adoption of new agricultural technology by farmers. Farmers who have higher formal year of education are expected to analyze information and adopt earlier than the uneducated persons; because farmers with higher education level are eager to grasp new ideas and to try the technology by allocating some proportion of their land. Hence education level and adoption have positive relationship.

Family size in adult-equivalent

As expected family size in adult-equivalent affects the adoption decision of farmers of the study area positively and significantly at 1% (t=2.65) significance level (Table 5). A unit increase in family size increases the probability of adoption by 2.34% whereas it increases the level of adoption among adopters and the total sample by 0.098 and 0.13 respectively (Table 6). This result is consistent with the study on adoption of improved maize seed by Motuma et al. (2010). From this; household with high number of family size in adult-equivalent adopts more agricultural technology (improved wheat technology) than households with low number of family size. This could be because households with high number of family size can undertake the agricultural activity in time and effectively manage the wheat fields. On the other hand, the increase in number of family members would urge the families to look for high productivity and return options to meet the demand for food and expenditure. These scenarios would increase the adoption of improved wheat technologies providing better options to meet the pressing demand.

Distance from the main road

This variable affects adoption decision of farmers negatively and significantly at 1% (t = -2.64) (Table 4). This result agrees with the study by Isaiah et al. (2007); according to his study; accesses to means of transportation affect positively adoption of improved barley varieties. A unit increase in distance from home to main road in kilometer decreases the probability of adoption in favour of adopters by 1.5% and it increases level of adoption by 0.063 among adopters and by 0.064 among the whole sample (Table 5). This implies that farmers near the main road adopts more than farmers away from the main road. Farmers near the road can get transportation facility easily and they can transport the improved wheat variety easily and at low cost than the other farmers.

Tropical livestock unite (TLU)

As expected TLU affects the adoption level of farmers positively and significantly at 1% (t = 4.42) level of significance (Table 4). A unit increase in TLU increases the probability of adoption by 5.56% and increases level of adoption by 0.021 and 0.025 among adopters and among the total sample respectively (Table 5). This implies that being owner of more livestock increase the level of adoption of improved agricultural technology. Livestock increases household income from sale of animals and farmers can finance their agricultural requirement easily from their livestock income. The study by Solomon et al. (2011) confirms this result. According to his study TLU affects adoption of agricultural technology positively and significantly.

Access to formal credit facility

As expected this institutional factor affected adoption level of improved wheat variety by farmers of the study area positively and significantly at significance level of 1% (t = 4.9) (Table 5). Results of analysis of marginal effects; show that having access to credit service increases the probability of being an adopter by 10.3% and it increases level of adoption by 0.42 and 0.51 among adopters and the total sample respectively (Table 6).

The reason behind is that most farmers of the study area suffers from shortage of money to purchase improved agricultural inputs and it force them to use the input what they have on hand; which is the local one. But having access to credit facility solves such type of problem and farmers can purchase the improved input. According to Namwata et al. (2010) access to credit facility affect adoption of improved agricultural technology for Irish potatoes positively and significantly. Also studies by Isaiah et al. (2007), Motuma et al. (2010) and Odoemenem and Obinne (2010) confirmed similar results.

Frequency of contact with extension agents

This variable represents the number in which extension agents visit farmer's field of production per month. As expected this institutional factor affects adoption of improved wheat variety of farmers of the study area positively and significantly at 1% significance level (t=3.38) (Table 5). According to Namwata et al. (2010) extension contact was affected adoption of improved agricultural technology for Irish potatoes positively and significantly. And also according to the study by Isaiah et al. (2007), Solomon et al. (2011), Ayinde et al. (2010), Odoemenem and Obinne (2010) and Matata et al. (2010) frequency of contact with extension agent affect positively and significantly adoption decision of farmers for improved agricultural technology. From the analysis of marginal effects a unit increase in frequency of contact with extension agent increases the probability of being an adopter by 2.18% and it increases level of adoption by 0.092 and 0.126 among adopters and the entire sample respectively (Table 6). This implies that contact with extension agent increases availability of information about the improved technologies to farmers. Farmers can learn more about the technology. Hence farmers with more contact with extension agents adopt more than farmers with less contact.

Perception of households about the cost of the technology

As expected this variable affects the adoption decision of farmers negatively and it was statistically significant at 1% (t = -3.07) level of significance (Table 5). From the analysis of marginal effect perceiving the cost of technology in high as compared with the local one decreases the probability of adoption of the improved wheat variety by 2.73% and it decreases adoption level of the technology by 0.0123 and 0.0145 for adopters and for the entire sample respectively (Table 5).

Distance from nearest market

This variable affects adoption decision of farmers negatively and significantly at 5% level of significance (Table 4). The study by Solomon et al. (2011) was consistent with this result; distance from nearest market affects adoption of improved agricultural technology negatively and significantly. And also the studies by Isaiah et al. (2007) and Mesfin (2005) were consistent with this result. Table 5 shows a unit increase in distance of the nearest market from farmers home decreases the probability of adoption by 6% and it decreases the level of adoption by 0.025 among adopters and by 0.028 among the entire sample. This implies that farmers nearest to market can get and buy the technology without any difficulties and it decreases transportation and marketing cost, in addition to this farmers nearest to market are nearest to any market information than farmers away from the market and they have updated market information.

CONCLUSION AND POLICY IMPLICATION

The use of improved variety is considered as the most important input for the achievement of increased agricultural productivity and food security status of farm households in Ethiopia. However, adoption of improved variety remains very low, especially among small-scale farmers of the country. The results of this study showed that variables like access to credit facility, family size in adult-equivalent, TLU, extension contact and education level of household head affect adoption of improved wheat variety positively and significantly. Whereas variables like distance from nearest market and main road and perception of households about cost of the technology affects adoption of improved wheat variety negatively and significantly.

The fact that access to extension service affect adoption of improved wheat variety positively and significantly; implies the important role the extension personnel played in order to impact farmers' attitude and enhance farmers' awareness on the benefit of improved wheat technology. This in turn implies the need for advancing farmers perception on the use and advantage of improved wheat technology to increase the sustainable food production. Therefore, the government and other stakeholders should encourage access to extension agents to enhance dissemination of improved wheat varieties among the farmers through workshops, seminars, trainings and pertinent demonstration activities.

Formal credit service had been found as one of the important factors affecting the adoption of improved wheat variety. As credit service should provide better ground for making improved decision to access improved inputs particularly those unaffordable to smallholder farmers through its effect of reducing the existing cash constraint for undertaking agricultural decisions and accessing high value inputs. Therefore it is recommended that credit service should be made available to farmers at an affordable rate to increase better and wider adoption of improved wheat technologies.

Distance from farmers' home to main road was an important variable which affects adoption of improved wheat variety negatively and significantly. Hence attention should be given to expand the road infrastructure in the rural area to increase farmer's access to transportation facility and decrease transaction cost to get better access to improved agricultural technologies. Perception of household towards cost of technology was significant variable which affect the adoption of improved wheat variety. Information about the benefits of new technology should be given for farmers to increase farmer's awareness about the technology and to develop farmer's attitude towards the technology. However, since in most cases cost is associated with the existing scenario of lack of capacity to buy the technologies, any agricultural development effort advocating the adoption of improved technologies should consider an enabling environment such as access to credit.

Conflict of Interest

The authors have not declared any conflict of interest.

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The empirical analysis of agricultural exports and economic growth in Nigeria

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Agriculture is both the main sector that is expected to provide employment to large segments of the population and the key to sustained economic growth of the countries. This study presented an empirical analysis of the effect of Agricultural Exports on economic growth of Nigeria. The model built for the study proxy gross domestic product as the endogenous variable measuring economic growth as a function of real exchange rate, real Agricultural exports, Index of Trade Openness and Inflation rate as the exogenous variables. Annual time series data was gathered from Central Bank of Nigeria Statistical bulletin, National Bureau of Statistics (NBS), CBN Economic and Financial Review Bulletin and CBN annual reports spanning from 1970 to 2012. The study used econometric techniques of Augmented Dickey-Fuller (ADF) unit root test, Johansen co-integration test and error correction method (ECM) for empirical analysis. The results of unit root suggested that index of trade openness and inflation rate was stationary at a level while real gross domestic product, real exchange rate and real agricultural exports were integrated at order one. The co-integration test showed that, long-run equilibrium relationship exist among the variables. The findings from the error correction method show that Agricultural Export has contributed positively to the Nigerian economy. The study recommended that, the government reform agenda should be systematic and sustained irrespective of the professional background of the successive presidents of the country and that; Agricultural production should be more desired than other sectors that are exhaustive in nature (oil) evidenced to the recent fall in price of crude oil which has rendered Nigeria in economic shambles.

Key words: Agricultural exports, economic growth, trade openness, Dutch disease and exchange rate.

INTRODUCTION

Agriculture has been the most important single activity in the Nigerian economy, with about 70% of the total working population engaged in it. It is the largest single sector of the economy, providing employment for a significant segment of the workforce and constituting the mainstay of the Nigeria large rural community which accounts for nearly two-third of the population. The proportion of the Gross Domestic Product (GDP) attributed to agriculture holds between 30 and 40% (CBN, 2009). The favourable climatic condition and vegetation makes Nigeria able to provide crops and livestock.

Generally, the rise of agricultural export has been a considerable success story and one that has brought numerous benefits to Nigeria thus, the importance of export to a nation's economic growth and development cannot be overemphasized since it is a catalyst necessary

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for the overall development of an economy (Abou-Stait, 2005). It is also a source of foreign exchange earnings since trade transaction among nations are settled in foreign exchange and employment opportunity for the people with the attendant reduction is social costs of unemployment. According to Usman and Salani (2008) a rewarding export drive can turn a hitherto underdeveloped economy into a prosperous activity through its multiplier effects on the level of national income since income earned through exporting will help in increasing the level of demand within the economy.

The Nigerian economy has been and is currently being characterized by a reasonable degree of openness; hence its performance can be enhanced through the development of the external sector. The Nigerian external sector has always been dominated by primary commodities (Agriculture) which have the well-known characteristics of low price and income elasticity of demand, low growth of demand, unbalanced terms of trade and instability of export earnings (Iyoha and Oriakhi, 2002). The decline in export earnings must have been engendered by short fall in production which has forced most developing countries to depend on importation of food. As a result of international specialization, the economic performance of the region over the years had been deplorable and disappointing, and this can be attributed to the growth in expenditure on food import and falling export earnings which has brought with it a deep economic mess and a growing balance of payment deficit coupled with using external debts (FMARD, 2014).

Agriculture, the second largest sector after oil, fell from 48% of GDP in 1970 to 20.6% in 1980 and was only 23.3% of GDP in 2005 (CBN, 2009). The sector's contribution to the growth of the Nigerian economy in 2012 stood at 39.21 and 41.93% improvement in the third quarter of 2013. This is because agricultural output continued to experience improved production in 2013. The sector recorded growth rate of 3.83% in the fourth quarter of 2012 as against 5.68 in the fourth quarter of 2011. Output in the third quarter of 2013 stood at 5.08%, up from the 3.89% recorded in the corresponding period of 2012 and also higher than the 4.52% recorded during the second quarter of 2013 with a low level of job creation as compared to education, financial intermediation, among others (NBS, 2013). Despite the involvement of Nigeria in international trade, hunger, malnutrition, mass poverty and high income among small groups of businessmen and politicians, unemployment and underemployment, lack of executive capacity, over dependence on petroleum and imports of goods and services continues to take a turn for the worse thereby leading to threat on economic growth in Nigeria. The duo crisis of food and finance around the world had left agricultural export and economic growth on its lowest ebb in Nigeria. These sluggish performances especially the decreased sector contribution from 6.5% in 2005 to 4.1% in 2012 of the agricultural sector and the vulnerability of the external sector thus dictate the urgent need to examine the trend and effect agricultural export on economic growth in Nigeria.

Objectives of the study

The study seeks to:

1. To examine the trend and composition of the agricultural export in Nigeria.
2. To determine the relationship between agricultural export and economic growth in Nigeria
3. To determine the impact of agricultural export on the Nigeria economy.

Scope of the study

The study examined the direction and the transmission channels of the relationship between growth and agricultural export within the period range from 1970 to 2012.

Conceptual framework

Economic growth

This is an increase in the capacity of an economy to produce goods and services, compared from one period of time to another. Economic growth can be measured in nominal terms, which includes inflation or in real terms which are adjusted for inflation. In order words, economic growth can be defined as the increase in the amount of goods and services produced by an economy over time. It is conventionally measured as the percentage of rate of increase in real gross domestic product or real GDP. Growth is usually calculated in real terms; that is, inflation adjusted terms to eliminate the distorting effect of inflation on the price of goods produced.

Determinants of economic growth in Nigeria

Economists regard factors of production as the main economic forces that determine growth. Some of the economic factors are explained as follows:

1. Natural resources: The principal factors affecting growth of an economy is the natural resources or land. "Land" as used in economics includes natural resources such as the fertility of land, its situation and composition, forest wealth, minerals, climate, water resources, sea resources, etc. for economic growth, the existence of

natural resources in abundance is essential.

2. Capital accumulation: The second important economic factor of economic growth is capital accumulation. Capital means the stock of physical reproduction of factors of production. When the capital stock increases with the passage of time, it is called capital accumulation (or capital formation). Capital formation is essential to meet the requirements of an increasing population in such economies; investment in capital goods not only raises production but also employment opportunities.

3. Organization: Organization is an important part of economic growth process. It relates to the optimum use of factors of production in economic activities, organization is complement to capital and labour and helps in increasing their productivities.

4. Technological progress: Technological changes are regarded as the most important factors in the process of economic growth. They are related to changes in the methods of production which are the result of some new techniques of research or innovations. Changes in technology leads to increase in productivity of labour and other factors of production.

5. Structural changes*:* Structural changes imply the transition from a traditional agricultural society to a modern industrial economy involving a radical transformation of existing institutions, social attitudes and motivations such as structural higher labour productivity and the stock of capital, exploitation of new resources and improvement in technology (Abou-stait, 2005).

Agricultural exports

In Nigeria, agricultural export has played a prominent role in economic development by providing the needed foreign exchange earnings for other capital development projects. According to Ekpo and Egwaikhide (1994) agricultural export commodities contributed well over 75% of total annual merchandise exports in 1960. Nigeria also ranked very high in the production and exportation of some major crops in the world in the 1940s and 1950s.

For instance, Nigeria was the largest exporter of palm oil and palm kernel, ranked second to Ghana in Cocoa and occupied a third position in groundnut. Olayide and Essang (1976) observed that Nigeria's export earnings from major agricultural crops contributed significantly to the Gross Domestic Product (GDP). Similarly, Ekpo and Egwaikhide (1994) observed a long-term relationship between agricultural exports and economic growth in Nigeria.

Theoretical framework

Vent for surplus theory which is propounded by Adam Smith explains the dynamics of international trade. It assumes the existence of surplus and idle human and material resources most especially within the underdeveloped countries. The theory emphasizes efficiency of production methods so that the resultant output exceeds by far the initial input resulting in surplus production. The theory may be underlined by the fact that international trade does not essentially determine factors of production but enhances the output of the surplus resources to be used to meet international demand. When the produce of any particular branch of industry exceeds what the demand of the country requires, the surplus must be sent abroad, and exchanged for something for which there is demand at home without such exportation, a part of the productive labour of the country must cease and the value of its annual produce diminish. By opening a more extensive market for whatever part of the produce of their labour may exceed the home consumption, it encourages them to improve its productive powers, and to augment its annual produce to the utmost, and thereby to increase the real revenue and wealth of the society.

Also, Scholars such as Hirschman, Rostow, Fleming and Singer propounded the theory of unbalanced growth as a strategy for development to be used by the underdeveloped countries. This theory stresses on the need of investment in strategic sectors of the economy instead of all the sectors simultaneously. According to this theory, the other sectors would automatically develop themselves through what is known as "Linkages effect". The theory argues that a deliberate unbalancing of the economy in accordance with predesigned strategy is the best way to achieve economic growth. "An ideal situation obtains when disequilibrium calls forth a development move which in turn leads to a similar disequilibrium and soon ad-infinitum". He observes that development has proceeded in this way with "growth being communicated from the leading sectors of the economy to the followers, from one industry to another, from one firm to another". Development process is a chain of disequilibrium that must be kept alive and the task of development policy is to maintain tension, disproportion and disequilibria.

More so, Corden and Neary (1982) pioneered the theoretical framework of the Dutch disease syndrome in their studies of how small open economies could be de-industrialized after having enjoyed a massively booming primary export sector. The Dutch disease theory states that a resource export boom has an inherent tendency to distort the structure of production in favour of the non-traded goods sector vis-à-vis the sectors producing the non-booming tradable. The impediments of oil revenue to economic growth and development of oil-dependent states is what is cumulatively called Dutch Disease in the literature of development economics (Otawa, 2001). The enormous influx of cash resulting from oil tends to foster, overzealous and imprudent expenditure. High oil revenue raises exchange rates, promotes adverse balance of payment as the cost of imports rises. In short, it kills incentive to risk investment in non-oil sectors, the competiveness of all non-oil sectors such as agriculture and manufacturing industries have been crowded out. The employment of both labour and other resources has been exchanged for unemployment as the government and private expenditure multipliers have been exported abroad. Together, these forces constitute what is called the rentier effect, oil sectors being "rentier states" (Michael 2001). The rentier state theory argues that countries depended on external rent like oil; develop a different bond of relationship between government and their citizens from those that rely primarily on taxation. Such states are less likely to be democratic than those that are tax reliant (Ayodele, 2004).

Theoretical linkage with the research problem

It is imperative and noteworthy to examine whether export growth can enhance growth to help curtail balance of payment deficit and to definitely establish whether the theories reviewed have any linkage to the stated problem under study. Using the Dutch disease theory, it states that the discovery of a natural resource (primary) has negative consequences resulting from any large increase in foreign currency including foreign direct investment, foreign aid or a substantial increase in natural resource prices. The impediments of oil revenue to economic growth and development of oil-dependent states at the neglect of other sectors is what is cumulatively called Dutch Disease in the literature of development economics (Otawa, 2001). The enormous influx of cash resulting from oil tends to foster, overzealous and imprudent expenditure. High oil revenue raises exchange rates, promotes adverse balance of payment as the cost of imports rises. In fact, it kills incentive to risk investment in non-oil sectors, the competiveness of all non-oil sectors such as agriculture and manufacturing industries have been crowded out. The employment of both labour and other resources has been exchanged for unemployment as the government and private expenditure multipliers have been exported abroad. Together, these forces constitute what is called the rentier effect, oil states being "rentier states". However, in Nigeria, government's spending went towards the non-traded sectors, not towards agriculture partly as a result of this neglect; Nigeria suffered a severe case of Dutch Disease. Therefore, it is evident that government can at least mitigate the effect of Dutch disease by actively subsidizing their traditional export sectors upon the discovery of oil.

More so, using the surplus theory propounded by Adam Smith which assumes the existence of surplus and idle human and material resources most especially within the developed countries. Under the vent-for-surplus approach, trade does not cause any reallocation of resources (here, labour) but rather assumes that more raw materials will be produced from the available surplus of land and labour. That is to say, trade here induces a 'vent' or an outlet for the unused resources (labour and land). Nigeria is using primitive techniques and adopts extensive cultivation of lands to produce more raw materials. But, once supply of land is exhausted, the further growth stops. Again, when prices of raw materials tend to rise because of inelasticity of supply against the rising demand, foreign trade eventually contracts and the country's growth process is sterilized further.

However, using the unbalanced growth theory, which posit the deliberate unbalancing of the economy according to a predesigned strategy in order to achieve growth in underdeveloped countries in Nigerian situation where oil sector is solely dependent upon has not proceeded its development by the way of communicating it (the leading sector) to the other sectors which agriculture is one of it. There is a lot of confusion of whether the unbalanced strategy of the Nigerian economy is deliberate or not and whether the development in the oil sector is really contributing to the development of other sectors like agriculture, manufacturing among others. This problem has remained the daily crop of tea to the young talented Nigerians who see the future of our economy since the so-called leading sector (oil) is exhaustible in nature.

Empirical review

Oji-Okoro (2011) employed multiple regression analysis to examine the contribution of agricultural sector on the Nigerian economic development. They found that a positive relationship between Gross Domestic Product (GDP) vis-à-vis domestic savings, government expenditure on agriculture and foreign direct investment between the periods of 1986 to 2007. It was also revealed in the study that 81% of the variation in GDP could be explained by domestic savings, government expenditure and foreign direct investment.

Olajide, et al. (2012) analyses the relationship between agricultural resources and economic growth in Nigeria. The ordinary least square regression method was used to analyze the data. The results revealed a positive cause and effect relationship between Gross Domestic Product (GDP) and agricultural output in Nigeria. Agricultural sector is estimated to contribute 34.4% variation in Gross Domestic Product (GDP) between 1970 and 2010 in Nigeria. The agricultural sector suffered neglect during the hey-days of the oil boom in the 1970s. In order to improve agriculture, government should see special incentives are given to farmers, provide adequate funding, and also provide infrastructural facilities such as good roads, pipe borne water and electricity.

RESEARCH METHODOLOGY

Research design

This research work is fundamentally analytical and descriptive as it embraces the use of secondary data in examining the role of agricultural commodity export in the economic growth of Nigeria. Of course, the descriptive tools consist of graphs and percentages, while the analytical tools consist of the econometrical tests specifically, unit root test, causality test and co-integration test.

Kinds and sources of data

The needed data for this research project include; data on Gross Domestic Product (GDP) at current basic prices, data on agricultural export, data on exchange rate, data for trade openness, data for inflation rate, data on real exchange rate. The data covered the period of 1970-2012. The data for this study was obtained mainly from secondary sources, particularly from Central Bank of Nigeria (CBN), CBN Economic and Financial Review Bulletin, CBN Monthly Reports, CBN Annual Reports, and Statements of Account of various years. Data sourced from Publication of the National Bureau of Statistics, Publication from the Internet and other related literatures.

Model specification

The model used for this project work is stated as follows:

Definitional form as:

RGDP = f (RAGREXP, REXR, ITOP, INFL) (1)

Stochastic form as:

$RGDP = b_0 + b_1RAGREXP + b_2REXR + b_3ITOP + b_4INFL + U_i$ (2)

Where, RGDP = Real Gross Domestic Product (Growth rate); RAGREXP = real agricultural export;
REXR = real exchange rate; ITOP = index of openness; INFL = inflation rate; b_0 = constant intercept;
b_1-b_4 = slope of coefficients of the explanatory variables captured in the model, and U_i = stochastic disturbance term.

Data analysis

The research work made use of descriptive statistical tools. This study also adopted the following test statistics: Stationarity test using the Augmented Dickey Fuller Test (ADF). The ADF formula is thus specified as:

$$\Delta P_{it} = \beta_1 + \beta_{2t} + \sigma P_{it-1} + \alpha \sum_{t-1}^{m} \Delta P_{it-1} + \varepsilon_{it} \quad (3)$$

Thus, Granger causality test was employed to determine the causal relationship between the variables under study. It is thus stated as:

$$y_t = a_0 + a_1 y_{t-1} + \ldots + a_l y_{t-l} + b_1 x_{t-1} + \ldots + b_l x_{t-l} + e_t \quad (4)$$

$$x_t = a_0 + a_1 x_{t-1} + \ldots + a_l x_{t-l} + b_1 y_{t-1} + \ldots + b_l y_{t-l} + u_t \quad (5)$$

for all possible pairs of series in the group. The reported *F*-statistics are the Wald statistics for the joint hypothesis: $b_1 = b_2 = \ldots = b_l = 0$ for each equation. The null hypothesis is that "… does *not* Granger-cause in the first regression and that … does *not* Granger-cause in the second regression". The ECM incorporates both the short run and the long run effects. When equilibrium holds $[Y_{t-1} - \beta_0 - \beta_1 X_{t-1}] = 0$ but in the short run when equilibrium exists, this term is non-zero and measures the distance by which the system is away from equilibrium during time t.

Data presentation and analysis

Trend analyses

The above graph represents the level of agriculture (non-oil) export on Nigerian economy. The diagram depicts an increasing trend of non-oil (agricultural) export over time though witness a stagnation as from (1970-1994) and fluctuations. It reveals that (2001-2012) there was an increase. Thus, this may be due to government policies over time to improve the non-oil export (agriculture) and in trying to diversify the Nigerian economy from oil sector to non-oil sector (Figure 1).

Unit root tests

The test results of the augmented Dickey-Fuller statistic for all the time series variables used in the estimation are presented in the Table 1.

These critical values are computed from Mackinnon (1996). If Z(t) ≥ ADF (t-statistic), it implies that unit root exist. If Z(t) ≤ ADF (t-statistic), it implies that unit root does not exist. From the unit test of the variables, both Inflation Rate (INFL) and index of trade openness (ITOP) are stationary (that is,l no unit root) at a level, that is, 1(0) while all other variables viz, Real Gross Domestic Product (RGDP), Real Exchange Rate (REXR) agricultural export (AGEXP) and achieved stationarity both at the first difference, that is, 1(1).

Causality

The results of granger causality are presented in the Table 2. From the Table, it revealed that, Agricultural Exports granger causes Economic growth, real exchange rate granger causes Agricultural Exports and Inflation rate granger causes Trade Openness both at 5% critical level in Nigeria.

RESULTS AND DISCUSSION

Johansen hypothesized co-integration result

The results are shown in Table 3. From the table, it revealed that there is co-integration among the variables. This is because the trace statistic of 70.35616 is greater than the critical value of 69.81889 at 5% level of significance. We reject the null hypothesis of none* of the hypothesized number of co-integration equations. Thus, trace statistic test indicates 1 co-integration equation at 5% level of significance. For the remaining number of hypothesized co-integration equation (At most 1, 2,3 and 4), we do not reject the null hypothesis as their trace statistics values are less than their critical values at 5% level of significance.

From Table 4, the Eigen value test shows that the null hypothesis of no co-integrating relationship against the alternative hypothesis is not accepted (that is, rejected) at 0.05 (5%) level of significance meaning that there is long-run relationship among the variables employed for the study, since they found that there is one co-integration equation at the given level of at most 1. Though, with

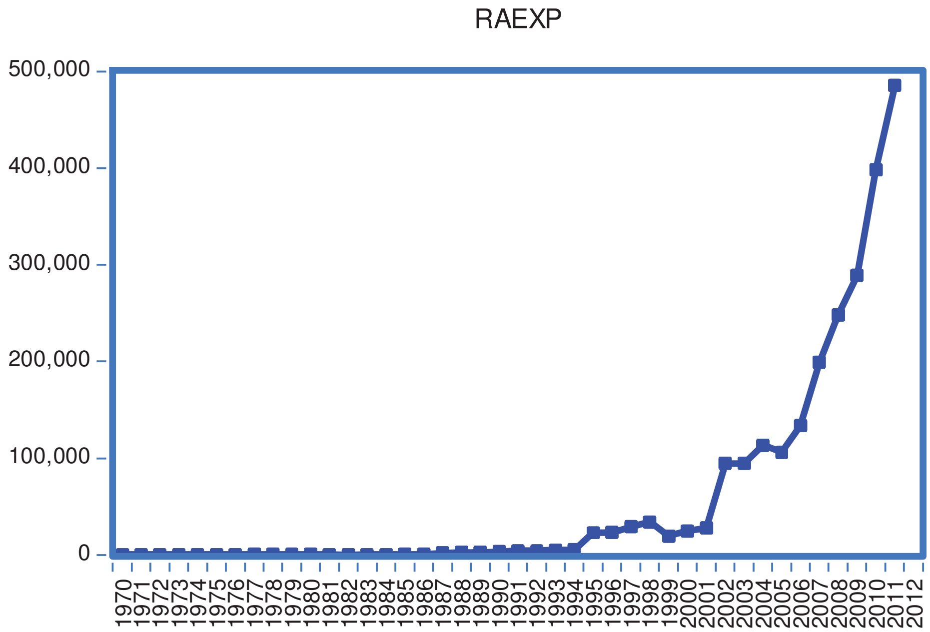

Figure 1. Trend of Agricultural Export in Nigeria (1970-2012).

Table 1. Unit root test for order of integration of variables (ADF).

Variables	At Level	First difference	Critical values (%)			Probability	Order of Integration
			1	5	10		
RGDP		-4.680381	-3.600987	-2.935001	-2.605836	0.0005	1 (1)
REXR		-5.982616	-3.600987	-2.935001	-2.605836	0.0000	1 (1)
RAGREXP		-3.941742	-3.600987	-2.935001	-2.605836	0.0040	1 (1)
ITOP	-3.573318		-3.596616	-2.933158	-2.604867	0.0106	1 (0)
INFL	-3.851488		-3.596616	-2.933158	-2.604867	0.0051	1 (0)

Source: Computed from the Unit Root Test (ADF).

Table 2. Granger Causality.

Pairwise Granger causality tests			
Lags: 2			
Null Hypothesis	**Obs**	**F-Statistic**	**Prob.**
ITOP does not Granger cause INFL	41	0.00135	0.9987
INFL does not Granger cause ITOP		4.58502	0.0168
REXR does not Granger cause RAGREXP	41	3.90728	0.0291
RAGREXP does not Granger cause REXR		0.00200	0.9980
RGDP does not Granger cause RAGREXP	41	2.59744	0.0884
RAGREXP does not Granger cause RGDP		4.90610	0.0134

Source: Granger causality test results.

these results, we can still conclude that, there is long-run relationship (co-integration) among the variables since both trace and max Eigen statistics shows at least 1 co-integrating equation. This implies that, there is a long-run

Table 3. Unrestricted co-integration rank test (Trace).

Null hypothesis	n-r	Hypothesized no. of CE(s)	Eigen value	Trace value	0.05 critical value	Probability
r = 0	4	None*	0.522817	70.35616	69.81889	0.0246
r ≤ 1	3	At most 1	0.297907	30.02207	47.85613	0.7179
r ≤ 2	2	At most 2	0.209927	15.52078	29.79707	0.7454
r ≤ 3	1	At most 3	0.115460	5.859943	15.49471	0.7120
r ≤ 4	0	At most 4	0.020035	0.829767	3.841466	0.3623

Source: e-views 7 output. Trace test indicates 1 co-integrating equation (s) at the 0.05 level; *, rejection of the hypothesis at the 0.05 leve;l **, Mackinnon-Haug-Michelis (1999) p-values.

Table 4. Unrestricted co-integration rank tests (maximum Eigen Value).

Null hypothesis	n-r	Hypothesized No. of CE(s)	Eigen Value	Trace Value	0.05 critical value	Probability
r = 0	4	None	0.522817	30.33409	33.87687	0.1250
r ≤ 1	3	At most 1	0.297907	14.50129	27.58434	0.7865
r ≤ 2	2	At most 2	0.209927	9.660837	21.13162	0.7758
r ≤ 3	1	At most 3	0.115460	5.030176	14.26460	0.7380
r ≤ 4	0	At most 4	0.020035	0.829767	3.841466	0.3623

Source: e-views 7 output. Max-Eigen value test indicates one co-integration at the 0.05 level of at most 1. *Rejection of the hypothesis at the 0.05 level. ** Mackinnon-Haug-Michelis (1999) P-values.

relationship between agricultural export and economic growth in Nigeria.

The impact of agricultural exports on economic growth in nigeria (Long-run)

The estimated model is stated as:

$$\underset{(3.74287)}{RGDP = -16.15516} + \underset{(4.45636)}{15.59997RAGREXP} - \underset{(0.975443)}{3.543275REXR} + \underset{(1.79503)}{1.114204ITOP} \underset{(1.15729)}{-3.027405INFL}$$

Standard errors are in parenthesis.

From the model, the estimates shows that holding all other variables constant, the RGDP will be negatively influenced by -16.15516. This is as a result of the increasing population which increases the cost of living among other factors. The coefficient of RAGREXP is correctly signed and is statistically significant at 5% level. This implies that a unit increase in Agricultural Export (RAGREXP) will lead to 15.59997 increases in economic growth (RGDP). Thus, there is a strong positive relationship between agricultural export and economic growth in Nigeria. More so, the coefficient of ITOP is correctly signed being positive, though the coefficient of Index of Trade openness is not statistically significant at 5% level. Thus, there is a strong positive relationship between Index of Trade openness and economic growth however, statistically insignificant. This implies that a unit increase in ITOP will lead to 1.114204 increases in economic growth in Nigeria.

On the other hand, the coefficient of real exchange rate is negative and statistically significant at 5% level. This implies that, a unit change in the real exchange rate will lead to 3.543275 decreases (that is, -3.543275) in Real Gross Domestic Product in Nigeria. Nevertheless, from the result of the normalized Johansen co-integrating equation, the coefficient of inflation rate is negative. This means that, inflation has a negative relationship with economic growth. Thus, any unit increase in inflation will lead to 3.027406 decreases (that is, -3.027406) in RGDP in Nigeria. This implies a long-run relationship.

Dynamic model (ECM)

The results are summarized in Table 5. From the results above, the error correction term is -1.33% indicating a very low speed of adjustment (that is, the speed at which the deviation from long-run equilibrium is adjusted slowly where 1.33% of the disequilibrium is removed each period). This shows that, the speed of adjustment to where agricultural export will equilibrate the real Gross Domestic Product in Nigeria is at the rate of 1.33%. More so, the coefficient of multiple determinations (R^2) from the model has a very high percentage contribution of 99.22% which means that, the independent variables were found to jointly explain 99.22% of the movement in the dependent variable with the negative $\bar{R}^2$ - adjusted of 0.723935. The explanatory variables include agricultural export, real exchange rate, Index of Trade Openness and

Table 5. The error-correction model.

Variable	Coefficient	Standard errors [t-statistic]
$RGDP_{t-1}$	-0.030845	0.19431 [-0.15874]
$RAGREXP_{t-1}$	0.360751	0.33352 [1.08164]
$REXR_{t-1}$	2.474386	4.77904 [0.51776]
$ITOP_{t-1}$	-5.324550	157.617 [-0.03378]
$INFL_{t-1}$	3.317342	5.46923 [0.60655]
ECM	-0.013328	0.03135 [-0.42518]
C	133.6902	78.7048 [1.69863]

Source: E-views Output, 2014. R^2 = 0.992236; $\bar{R}^2$ = 0.723935; F – Statistic = 8.086943.

inflation rate. The fitness of the model is explained by the F-statistic which is 8.086943. The Akaike information criterion is also indicating how good the model is coefficient of the short-run dynamics shows that real agricultural exports is statistically significant at 5% critical level indicating that, the rate of agricultural exports and economic growth significantly affect growth of the economy in the short-run. This means that, agricultural exports contribute significantly to the growth of the Nigerian economy.

Based on the standard error test, since the value of $S(b_2)$ = 4.45636 is less than the value of ½ of b_2 (15.59997), this research therefore rejects the null hypothesis and the alternative hypothesis is accepted. That is, agricultural exports impact positively on the economic growth of Nigeria. It can therefore be inferred from this research findings and from the various studies cited in the literature that agricultural exports has great effect (positive) on the economic growth of Nigeria in both long-run and short-run.

Summary of findings

The study revealed that, most of the variables (RGDP, REXP and RAGREXP) achieved stationarity at first difference except Inflation rate (INFL) and Index of Trade Openness (ITOP) that achieved stationarity at level. The information was made with the use of augmented Dickey-Fuller test which implies that, spurious result is avoided. The synergy of some explanatory variables will exert a positive influence on the real GDP while it will exert negatively on other variables.

It was also observed that, the trend of Index of Trade Openness has a serious impact on the GDP of the Nigerian economy. This is because amidst stagnations in the Index of Trade Openness, there was an increase from 1970 to 1974 and continued from 1987 where it took its pick in 1996 and began to decrease continuously with many fluctuations. This is as a result of placement and withdrawal of trade barriers and tariffs. However, even small countries benefits greatly but relatively small in international trade as it opens doors for export of unused agricultural resources and the effect of high prices at the international market. Therefore, trade openness allows two or more nations to trade in other to share their benefits (comparative advantage) as well as increase their foreign reserve.

It was also observed that, agricultural exports are important drive of economic growth at the macroeconomic level and there is a strong empirical evidence of a positive relationship between agricultural exports and economic growth at the macroeconomic level in both short-run and long-run.

The severe reduction in agricultural exports is further indications of the week competitiveness of Nigerian agriculture. Nigeria has lost market share for exports such as cocoa, palm oil and rubber. Non-traditional exports are limited while agricultural exports have strengthened since 2000; performance is still far below the economy's potentials. This is because Nigeria has clear potential to earn more from agricultural exports both in traditional commodities such as cocoa, rubber, palm produce, Cotton, hides and skins, crafts and textiles and in non-traditional ones. There are also immense opportunities to be tapped from the development of non-traditional exports such as Non-Timber Forest Products (NTFPs) including medicinal plants, snails, mushrooms, cultivated wildlife and so on. Some of these products are in high demand in North America, Europe and Asia where niche markets exist for them. Besides the diversification in foreign exchange revenue for the country, other economic opportunities in this sector include income generation and gainful employment at both production and value addition stages.

From the result of the long-run relationship (co-integration), Johansen hypothesized co-integration (trace test) indicated 1 co-integrating equation however Max-Eigen value indicated no co-integrating equation. Thus, with the revealed co-integrating equation by trace test, there exists long-run relationship amongst the variables.

More so, the study revealed a low speed of adjustment. That is, the estimated coefficient indicates that about 1.33% of this disequilibrium is corrected between one (1) year (since the data is annually) This means that, the speed of adjustment to where the agricultural export will equilibrate the real Gross Domestic Product in Nigeria is at the rate of 1.33%

Conclusion

Empirical evidence from these analyses and results have shown that agricultural export can be as lucrative and profitable as any other sector of the Nigerian economy with respect to returns on investment. Therefore, the discrimination against agriculture and the negative perception and orientation of the average Nigerian about agricultural sector should disabused so that these sectors can contribute optimally to GDP upon channeling investment to agriculture because of the high potentials for employment, food security and exports. More so, since recent shock in oil prices could render Nigeria in economic shambles, much attention is needed in the agricultural sector to overcome such subsequent challenges.

Recommendations

This study recommends that, the reform agenda should be systematic and sustainable irrespective of the professional background of the successive presidents of the country. In the short run, the strategy of the government should be to improve the competitiveness of Nigerian agriculture in domestic and regional markets. As agricultural growth will continue to be led by smallholders' farmers, policy-makers should take bold actions to:

1. Improve resource and development investment in agricultural research: This is because for agricultural productivity to improve Nigeria's farmers need access to new technology. Technology alone will not solve the problem of low productivity, but it is a necessary condition. In particular, the government will also need to improve its research and extension services in order to improve the use of genetic materials and purchase inputs.
2. Improve markets, infrastructure and institutions: This is because fair, properly functioning markets and access to both inputs and food at reasonable prices are needed for poor Nigerian farmers to dully capture the benefits from access to credit, productive inputs (especially inorganic fertilizers) and extension services are needed, policies (like taxes and subsidies) that create distortions in capital to small-scale farmers must be removed.
3. Improved irrigation capacity: Productivity in Nigerian agriculture is low, in part because of the low yield levels and the high yield variability associated with rain-fed agriculture that discourage farmers from investing in inputs such as improved seed, fertilizers and crop protection chemicals. Irrigation can serve as a powerful stimulus to agricultural growth by raising biological yield potential and increasing returns to investments in complementary inputs.
4. Strengthen the agricultural input supply systems: there will be no growth in agricultural productivity and exports unless Nigerian farmers increase their use of purchased inputs, especially improved varieties of seed, chemical fertilizers, crop protection chemicals, including pesticides, herbicides and fungicides, and animal health-related products such as vaccines, medications and nutritional supplements. Strengthening inputs supply systems will ensure that these inputs are available in a timely fashion and at affordable prices.
5. Provision of adequate funds for farmers: Government should provide funds to acquire sophisticated farm tools and increase her budgeting allocation to this sector in a consistent manner because of its importance to the national economy hoping that with proper monitoring of fund, it would contribute more significantly to the economy of the country. As effective utilization of such funds is also advocated and all areas of wastage blocked. These actions will go a long way to improving agricultural growth and exports.
6. Diversification of the Nigeria economy: The Nigerian government should make all necessary efforts in dervisifying the economy in order to avoid complete disorder. Thus, much should be invested in Nigerian agricultural sector that has the potentials and high competitive advantage in the international market.

Conflict of Interest

The authors have not declared any conflict of interest.

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