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Abstract
Although many countries have made significant progress in the last decade, poverty and malnutrition continue to be major problems in Sub-Saharan Africa. Experts estimate that rising food prices have driven about 44 million people into poverty in developing countries since June 2010, as food costs continue to rise. Innovation adoption is key to increasing farm productivity. This necessited this study on innovation adoption, farm productivity and poverty status of rural smallholder farm households in South-Eastern Nigeria. This was premised on the fact that increasing agricultural productivity can increase food availability and access as well as rural incomes as the rural areas are home to 75 percent of Africa's population, most of whom count agriculture as their major source of income. Data collected using structured questionnaire and interview schedules were analyzed using descriptive statistical tools such as frequency tables, percentages, regression analysis and Chow's test statistic. Result of data analysis revealed that the most adopted innovations/technologies were use of inorganic fertilizer, improved seed, terracing, crop residue recycling, crop rotation and use animal waste. The significant factors influencing adoption of the innovations/technologies were gender, age, years of formal education attainment, household income, extension contact and membership of cooperative. The Chow's test revealed that innovation/technology adoption have significant and positive impact on farm productivity. Also, the study revealed improved livelihood or better welfare for innovation adopters than for non-adopters. Therefore, efforts at increasing farm productivity and reducing poverty among farm households should involve policies that would encourage the households to embrace or step up adoption of agricultural innovations should be put in place. This should involve educating and enlightening the farm households on the benefits of these innovation. In this respect, agricultural extension services should be strengthened to provide the informal training that helps to unlock the natural talents and inherent enterprising qualities of the farm households, enhancing his ability to understand and evaluate new production techniques/innovations leading to increased farm productivity and incomes with concomitant reduction in poverty.

Keywords: Innovation, Adoption, Productivity, Poverty

Introduction

Global food insecurty remains a serious problem and more than 900 million people are still hungry in 2010 (Fan and Brzeska 2010). Poverty and malnutrition continue to be major problems in Sub-Saharan Africa. Agricultural production increased to 12.3 percent of gross domestic product in 2009. Yet, 72.9 percent of the population live on less than US$2 per day, 27.5 percent consume inadequate calories, and 23.6 percent of children under five are underweight. The issue of increasing agricultural productivity has become the main concern to governments following considerable increase in food price over the last two years that follows decades of low food price (Conradie et al. 2009).

Increasing agricultural productivity can increase food availability and access as well as rural incomes. Rural areas are home to 75 percent of Africa's population, most of whom count agriculture as their major source of income. Fortunately, Africa has experienced continuous agricultural growth during the last few years. However, much of the growth has emanated from area expansion rather than increases in land productivity. Rahman and Rahman (2008) noted that the principal solution to increase food production lies in raising the productivity of land given the existing varietal mix. In most countries, future sustainable agricultural growth will require a greater emphasis on productivity growth, as suitable area for new cultivation declines, particularly given growing concerns about deforestation and climate change.

The conceptualization of poverty in terms of the risk and vulnerability of those that are poor has emerged at a time when poverty reduction has become an important aspect of the national economic and social policy mix in many developing countries. Omenugha (2001) noted that poverty reduction programmes and policies when tied with growth enhancement policies are a high priority in national policy design in countries suffering from increasing population pressures and deteriorating living and economic conditions. The first step in reducing poverty and hunger in developing countries, according to Fan (2010), is to invest in agriculture and rural development. He noted that most of the world's poor and hungry people live in rural areas in Africa and Asia and depend on agriculture for their livelihoods, but many developing countries continue to underinvest in agriculture. Research has shown that investments in agricultural reserach and extension have large impacts on agricultural productivity and poverty. Recent debates in the growth-poverty nexus point to the fact that the poor are likely to benefit from growth if such growth occurs in sectors in which a large proportion of the poor actively participate and derive their livelihoods (Hoekman *et al.,* 2001).

As measured by the 2010 Global Hunger Index (GHI), Sub-Saharan Africa's GHI reduction was only 14 percent (compared to its 1990 level). GHI fell by about 26 percent in South Asia, 33 percent in the Near East and North Africa, and more than 40 percent in Southeast Asia and Latin America and the Caribbean. It is likely that many African countries will not meet Millennium Development Goal (MDG) 1—halving poverty and hunger by 2015. High food prices in 2007–08—which exacerbated the problems of hunger and poverty—resurfaced in the middle of 2010. In many of the world's poorest countries, food accounts for over half of household expenditures, and increased food prices seriously reduce both access to food and ability to purchase other necessities (von Grebmer *et al.* 2011). Experts estimate that rising food prices have driven about 44 million people into poverty in developing countries since June 2010, as food costs continue to rise to near 2008 levels. In the short run, various measures to increase availability and access to food, including promotion of private trade, government market interventions, and safety nets, may be needed. In the medium term, however, sustainable food security in most countries will require increases in domestic food production as well.

The large gap between potential and current crop yields makes increased food production attainable. Africa's low agricultural productivity has many causes, including scarce and scant knowledge of improved practices, low use of improved seed, low fertilizer use, inadequate irrigation, conflict, absence of strong institutions, ineffective policies, lack of incentives, and prevalence of diseases. With scarcity of land, water, energy, and other natural resources, meeting the demands for food and fiber will require increases in productivity.

Innovation adoption is key to increasing farm productivity. Kohli and Singh (1997) found that inputs played a large role in the rapid adoption of high yielding varieties and that effort made to make the technological innovations and their complementary inputs more easily and cheaply available allowed the technology to diffuse faster. An influential body of literature on technology adoption has focused on the effect of social learning on adoption decisions. According to Uaiene (2011), the basic motivation behind this literature is the idea that a farmer in a village observes the behavior of neighboring farmers, including their experimentation with new technology. Once a year's harvest is realized, the farmer then updates his priors concerning the technology which may increase his probability of adopting the new technology in the subsequent year.

Conley and Udry (2002), in Uaiene (2011), looking at pineapple cultivation in Ghana, analyzed whether an individual farmer's fertilizer use responds to changes in information about the fertilizer productivity of his neighbor. They found that a farmer increases (decreases) his fertilizer use when a neighbor experienced higher than expected profits using more (less) fertilizer than he did, indicating the importance of social learning.

Bandiera and Rasul (2006) found that the probability of adoption is higher amongst farmers who reported discussing agriculture with others. Besley and Case (1993) use a model of learning where the profitability of adoption is uncertain and exogenous. Looking at a village in India, they found that once farmers discover the true profitability of adopting the new technology, they are more likely to adopt. Foster and Rosenzweig (1995) and Conley and Udry (2002) use a target-input model of new technology which assumes that the best use of inputs is what is unknown and stochastic. Applying this model to high yielding varieties adoption in India, Foster and Rosenzweig (1995) found that initially farmers may not adopt a new technology because of imperfect knowledge about management of the new technology; however, adoption eventually occurs due to own experience and neighbours' experience.

Most rural households lack access to to reliable and affordable innovations which have the potential to improve their livelihoods and food security status (Fan 2011). In this guise, non financial services such as marketing and extension services offers new opportunities for small farmers to increase their productivity and incomes.

The already fragile food security situation in SSA is at risk from emerging stress factors. To reduce poverty and hunger in the region, there is an urgent need for global, national, and local actors to pursue innovative approaches to improve agricultural productivity. This necessitated this study on innovation adoption, farm productivity and poverty status of rural smallholder farm households in South-east, Nigeria.

Methodology

This study was conducted in South Eastern Nigeria, which comprises of five states namely: Abia, Anambra, Ebonyi, Enugu and Imo. The area lies between latitudes 4^0 20^1 and 7^0 25^1 North and longitudes 5^0 25^1 and 8^0 51^1 East. It covers a land area of about 109, 524KM^2 or 11.86 percent of the total land area of Nigeria. The area lies mainly on plains under 200M above sea level (Obi and Salako 1995; Monanu 1975). The population of the area is 29,949,530, comprising of 15, 326,463 males and 14, 623,067 females (NPC 2006) and farming is the predominant occupation of the rural inhabitants. According to Nwajiuba (2005), four states in Southeast Nigeria (Anambra, Imo, Abia and Enugu) are among the seven most densely populated states of Nigeria, implying that the Southeast is the most densely populated area in Nigeria. As a result, there is increased human pressure on agricultural land. Expansion of land area becomes difficult and yield increases are likely to come from adoption of improved farming techniques and innovations.

A multi-stage random sampling and purposive sampling technique was used in choosing the sample. In the first stage, 2 States, Abia and Imo, were randomly selected from the 5 states in South Eastern Nigeria. Secondly, from each State, all rural Local Government Areas (LGAs) were purposively selected to ensure homogeneity of the sampling units and the random selection of 5 LGAs from the list formed the third stage. In the fourth stage, 4 communities were randomly selected and 2 villages were randomly selected from each chosen community. The purposive selection of arable crop farm households formed the respective sampling frames in each chosen village, from which 3 households each were randomly selected. In all, 120 respondents were used for the study comprising. These were disaggregated into two groups, adopters and non-adopters based on their degree of adoption of improved innovations/technologies.

Data collected using structured questionnaire and interview schedules were analyzed using descriptive and inferential statistical tools such as frequency tables, percentages, regression analysis and Chow's test statistic. Data analysis was by the use of such statistical tools as Z test, regression analysis and Chow's test statistic. For factors influencing adoption of innovation/technologies, the probit regression model was analyzed. It is given by:

$$P(Y_i = 1/\chi) = \Phi(\chi' \beta) = \int_{-\infty}^{\chi' \beta} 1/\sqrt{2\pi} \exp(-z^2/2)dz \qquad (1)$$

Where P is the probability that the ith household used the new technology, and 0 otherwise. The probit model is generated by a simple latent model of the form, $Y^* = \chi' \beta + \varepsilon$ (2)

Where $x|\varepsilon$ is a normally distributed error term; Y is the index of use of technologies/innovation measured as Y = (U/V)*100, where U is the participatory score of the respondent household on the number of technologies/innovations adopted and V is the overall score of all the innovations available. (NB: households with adoption index < 50% are regarded as non-adopters, and households with index ≥ 50% are regarded as adopters). X is a vector of explanatory variables such as gender of the farm household head (head gender), age farm household head (head age), household size, years of formal education of farm household head (schooling), extension contact, household income, household assets' endowment, access to credit, and membership to an agricultural association/cooperative society.

In order to ascertain the impact of adoption on output, a Cobb-Douglas production function was specified and analyzed for the two groups of households separately and then the pooled data was equally analyzed (equation 1). The pooled data with a dummy variable (equation 2) representing household type was equally analyzed. The implicit forms of the models are specified as:

$$Y = f(X_{1i}, X_{2i}, X_{3i}, X_{4i}) \qquad (3)$$

(i = 1,2)

$$Y = f(X_1, X_2, X_3, X_4, D) \qquad (4)$$

Where in equations (3) and (4), Y is the grain equivalent output of arable crop in kg (Olayemi, 19986); X_1 is farm size in hectares; X_2 is labour measured in mandays; X_3 is other variable inputs which include planting materials, fertilizer and other agrochemicals, etc in naira; X_4 is capital in naira which is made up of depreciation costs, interest on loans, etc; D is a dummy (1= households with adoption index ≥ 50% or adopters and 0= households with index < 50% or non-adopters) and i represent the farm household group.

The Chow's test statistic was used to test if there was significant difference in production function of the two groups of households and is computed following Olomola (1998), Onyenweaku (1997), Thamodaran *et al.* (1982) and Johnston (1972). The Chow's test for production change (structural shift in production function) is given by:

$$F^* = \frac{[\Sigma e^2_3 - (\Sigma e^2_1 + \Sigma e^2_2)] / [k_3 - k_1 - k_2]}{(\Sigma e^2_1 + \Sigma e^2_2) / (k_1 + k_2)} \qquad (5)$$

Where in (5), Σe^2_3 and k_3 are the error sum of square and degree of freedom respectively of the pooled data; Σe^2_1 and k_1 are the error sum of square and degree of freedom respectively of the sample of adopters; and Σe^2_2 and k_2 are the error sum of square and degree of freedom respectively of the sample of non-adopters.

For the test for homogeneity of slope, the Chow's F statistic is calculated as follows:

$$F^* = \frac{[\Sigma e^2_4 - (\Sigma e^2_1 + \Sigma e^2_2)] / [k_4 - k_1 - k_2]}{(\Sigma e^2_1 + \Sigma e^2_2) / (k_1 + k_2)} \qquad (6)$$

Where in equation (6), Σe^2_4 and k_4 = the error sum of square and degree of freedom respectively for the pooled data with a dummy variable with a value of unity for adopters and zero for non-adopters, while other variables were as previously defined.

For the test for differences in intercepts, the chow's F statistic is calculated as follows:

$$F^* = \frac{[\Sigma e^2_3 - \Sigma e^2_4)] / [k_3 - k_4]}{\Sigma e^2_4 / k_4} \qquad (7)$$

Where all variables in equation (7) were as previously defined.

The theoretical value of F is the value that defines the critical region of the test at the chosen level of confidence (Koutsoyiannis 2001). If the calculated F exceeds the tabulated F value, then the intercepts are assumed to be different between the households. This test is conditional on a common slope, so the test for differences in slopes is performed first before testing for differences in intercepts (Onyenweaku 1997).

The determination of the poverty status of the two groups of farm households were realized using Per Capital Household Food Expenditure (PCHFE).

$$\text{Per capital house food expenditure} = \frac{\text{Total household monthly expenditure}}{\text{Household size}} \qquad (8)$$

The classification of household poverty status was based on Mean Per Capita Household Expenditure (MCHE).

$$\text{MCHE} = \frac{\text{Total per capita household expenditure}}{\text{Total number of household}} \qquad (9)$$

The poverty line is then drawn from the mean per capita household total expenditure, to get two mutually exclusive classes and the classification of the rural dwellers. This was done as follows:

1. Rural household whose PCTHE is equal to or greater than 2/3 mean of PCTHE are considered non poor.

2. Rural household whose PCTHE is less than 2/3 mean PCTHE. There farmers are considered poor.

A core poor (extreme poverty) was defined as 1/3 of the mean per capita total household expenditure. Rural dwellers with per capita total house hold expenditure less than this would be considered extremely poor. Rural household whose expenditure falls between core poor and below 2/3 PCTHE are considered moderately poor.

The impact of adoption on poverty status of the farmers was analyzed using Ordinary Least Square (OLS) methods and Chow's test.

The model is stated implicitly as follows:

$$\text{Log PCEi} = f(X_{1i}, X_{2i}, X_{3i}, X_{4i}, X_{5i}, X_{6i}) \qquad (10)$$

(i = 1,2)

$$\text{Log PCE} = f(X_1, X_2, X_3, X_4, X_5, X_6, D) \qquad (11)$$

Where: Log PCE is log of per capita household food expenditure per adult equivalent (AE), derived as: AE = 1 + 0.7 (n_1-1) +0.5n_2; n_1 = number of adults aged 15 years and above; n_2 = number of children aged less than 15 years; X_1= sex (gender); X_2= age (years); X_3= household size (number of people living with the respondents); X_4= total land holding (hectare); X_5= income (naira); X_6= educational level (years); and D is as previously defined in equation (4).

The Chow's test was applied following same procedure outlined in equations (5) to (7) for test of poverty effect, homogeneity of slopes, and for difference in intercepts.

Results and Discussion

Adoption of improved technologies/innovations

The distribution of the farm households based on their adoption of improved innovations is presented in Table 1. The Table revealed that that the most adopted innovations/technologies were use of inorganic fertilizer, improved seed, terracing, crop residue recycling, crop rotation and use animal waste. The high rates recorded may be due to their wide diffusion which in itself results from a series of individual decisions to begin using the new technology, decisions which are often the result of a comparison of the uncertain benefits of the new invention with the uncertain costs of adopting it. The low technology usage as in the case of tractor services is circumscribed by land fragmentation which hinders farm mechanization. The result in Table 1 suggests that ample opportunities exist for the farmers to increase their use of the new technologies and thus improve on the productivity.

Table 1: Adoption of improved technologies/innovations

Innovation/technology adopted	Frequency of adoption*	Percentage
Inorganic fertilizer	120	100.00
Herbicide	35	29.17
Improved seeds	95	79.17
Tractor use	6	5.00
Crop residue recycling	65	54.17
Crop rotation	69	57.50
Contouring	39	32.50
Terracing	84	70.00
Zero tillage	50	41.67
Green manuring	45	37.50
Use animal waste	73	60.83
Use of organic fertilizer	58	48.33

Source: Field survey data, 2 011
*Multiple responses recorded

Factors influencing adoption of innovations/technologies
The probit estimates of the factors influencing adoption of the technologies is presented in Table 2. The likelihood ratio Chi-square (χ^2) was highly significant at 1% indicating the goodness-of-fit of the estimated model and the coefficient of determination was 0.774, which implies that 77.4% of the variations in adoption of the technologies were explained by the variables included in the model. The significant factors influencing adoption of the innovations/technologies were gender, age, years of formal education attainment, household income, extension contact and membership of cooperative.

Table 2: Probit estimate of the factors influencing adoption of innovations/technologies

Variables	Coefficient	Std. error	Z
Intercept	-4.017	1.907	-2.11**
Gender	0.288	0.091	3.16***
Age	-0.070	0.021	-3.34***
Access to credit	0.273	0.189	1.44
Household size	-0.333	0.237	-1.41
Education	0.038	0.012	3.17***
Household income	0.0009	0.0003	2.92***
Assets	7.32e-06	5.44e-06	1.35
Extension contact	0.385	0.152	2.53***
Membership of farmers' association	0.034	0.014	2.38**
Likelihood ratio chi square		33.06***	
Pseudo R^2		0.774	

Source: Field survey data, 2 011
*** is significant at 1%, ** is significant at 5% * is significant at 10%

The coefficient of gender is significant at 1% and positively related to adoption. This implies that adoption of new technology is higher for male headed households. This has a bearing on the lopsidedness of extension services, the major means of innovation diffusion. FAO (2005) reported that few extension services are targeted at rural women, few of the world's extension agents are women and most of the extension services focus on commercial rather than subsistence crops-the primary concern of women.

The coefficient for age was negative and significant at 5% probability level indicating adoption of new technology decreases with age. It has been noted that the older one becomes the more risk averse he/she is. This explains the negative relationship between adoption of new innovations and age.

The coefficient of household income was significant at 1% probability level and positively related to innovation adoption. This implies that innovation adoption increases with increase in income. Krause et al. (1990), Immink and Alarcon (1993) and Iheke (2006) noted that lack of fund and access to credit prohibits smallholder farmers from assuming risks of financial leverage associated with the adoption of new technology

According to Iheke (2010), education increases the ability of the farmers to adopt agricultural innovation and hence improve their productivity and efficiency. This explains the direct relationship between education and adoption at 1% significance level. Obasi (1991) stated that the level of education of a farmer not only increases his farm productivity but also enhances his ability to understand and evaluate new production techniques.

While extension services provide informal training that helps to unlock the natural talents and inherent enterprising qualities of the farmer, enhancing his ability to understand and evaluate and adopt new production techniques leading to increased farm productivity, cooperative societies/ farmers' associations are sources of good quality inputs, labour, credit, information and organized marketing of products. These explain their significant and positive relationship with adoption of improved technologies. They are expected to help them to receive and synthesize new information and innovations his locality and beyond.

Estimated production function

The result estimated production functions for the to groups of households, the pooled data, and the pooled data with dummy is presented in Table 3. All the F-ratios were all statistically significant at 1% level indicating the goodness of fit of the model. The coefficient of multiple determination were 0.6815, 0.5200, 0.7512, and 0.5957 for the adopters, non-adopters, the pooled data and the pooled data with dummy indicating household type, respectively. These imply that 68.15%, 52%, 75.12%, and 59.57% of the variations in the outputs of the innovation adopters, non-adopters, the pooled data and the pooled data with dummy indicating household type respectively, were accounted for by the variables included in the models.

The significant factors influencing the output of the adopters were farm size, labour, other variable inputs like fertilzer and agrochemicals, planting materials, etc, and capital which were all positively related to output and significant at 1% significance level except for capital thatwas significant at 5%; while for the non-adopters, the significant factors influencing their output were farm size, labour and capital which were all positively related to output. Farm size was significant at 1% while labour and capital were respectively significant at 5% level of significance. These imply that increased employment of these variables, *ceteris paribus*, would lead to increase in output. These are consistent with *a priori* expectation.

Table 3: Estimated Cobb-Douglas Production Function of the Households

Parameters	Innovation adopters		Non-adopters		Pooled		Pooled D	
	Coeff	t-ratio	Coeff	t-ratio	Coeff	t-ratio	Coeff	t-ratio
Constant	3.888	12.31***	3.796	5.45***	1.392	1.24	0.138	3.54
Farm size	0.138	3.54***	8.327	3.21***	0.476	2.26**	-0.006	-0.23
Labour	0.026	8.11***	0.296	1.98**	-0.045	-2.17**	0.941	1.45
Other variable inputs	0.075	3.56***	0.173	1.12	0.304	0.72	0.057	1.72*
Capital	0.449	2.34**	1.017	2.27**	0.042	8.35***	0.449	2.23**
Dummy							2.686	7.00***
R^2		0.6815		0.5200		0.7512		0.5957
Adj R^2		0.6454		0.5041		0.7006		0.5215
F ratio		3.40***		2.92***		6.17***		5.20***

Source: Survey data, 2011

***, **, and * = significant at 1%, 5% and 10% levels respectively.

For the pooled data, farm size and capital were positively related to output at 5% and 1% levels, respectively; while labour was significant at 5 percent level and negatively related to output of the farmers. This does not conform to *a priori* expectation as it implies that increased use of labour would lead to decrease in output. However, the negative relationship must have resulted from increased use of labour beyond the point of its economic optimum or to the point of diminishing marginal productivity.

The dummy representing household type was significant at 1% and positively related to output. This result implies that innovation adopters obtained higher output than the non-adopters. This is as a result of gains from use of new and improved crop varieties and technologies.

Tests for structural shift in production function and differences in output

The results of the statistical tests for structural shift in production function and differences in output were presented in Table 4. The calculated chow's F statistic for production effect was significant at 1%. The result confirms that there is significant difference between the production functions of the adopters and non-adopters of innovations. In other words, the innovation adopters are associated with structural modifications of their production parameters, implying that the production functions of the households differ.

Table 4: Tests for difference in output

Nature of analysis/Household type	Error sum of squares	Degrees of freedom	Calculated F
Tests for output effects			
Innovation adopters	5.2814	51	14.675***
Non- adopters	4.8389	59	
Pooled data	32.398	115	
Tests for homogeneity of slope			
Innovation adopters	5.2814	51	8.833***
Non- adopters	4.8389	59	
Pooled data with dummy	22.635	114	
Test for differences in intercept			
Pooled data	32.398	115	49.171***
Pooled data with dummy	22.635	114	

Source: Survey data, 2011 *** = significant at 1 percent

The result of the test for homogeneity of slopes in the production functions of innovation adopters and non-adopters show that the calculated Chow's F statistic is statistically significant at 1%. The result confirms heterogeneity of slopes or factor biased production functions.

The calculated chow's F statistic for the test for differences in intercept is significant at 1%. This result confirmed heterogeneity of intercepts for the innovation adopters and non-adopters and output advantage for the remittance receiving households derivable from the use of remittance income. This confirms the result of the pooled data with dummy variable representing household type which revealed that remittance receiving households obtained higher output relative to the non-remittance receiving households.

Distribution of household groups based on their poverty status

The distribution of the household groups according to their poverty status is presented in Table 5. The Table revealed that, comparatively, the innovation adopters had better livelihood than the non adopters. The first step in reducing poverty and hunger in developing countries, according to Fan (2010), is to invest in agriculture and rural development. Innovations are products of research and investments in agricultural reserach and extension have large impacts on agricultural productivity and poverty. Therefore, innovation adoption is crucial for broad–based growth and poverty reduction.

Table 5: Percentage distribution of household groups based on their poverty status

Poverty status	Innovation adopters		Non-adopters	
	Frequency	Percentage	Frequency	Percentage
Non-poor	36	64.29	31	48.44
Poor	13	23.21	20	31.25
Extremely poor	7	12.50	13	20.31
Total	56	100	64	100

Source: field survey, 2011

Poverty functions of the households

The poverty functions of the households (adopters, non-adopters, the pooled sample and the pooled sample with a dummy variable representing household type is presented in Table 6. The Table revealed that sex of household head was significant at 1% and positively related to poverty status of the households. This implies that male headed households have better livelihoods than female headed households. Etim *et al*. (2011) reported that gender of the household head was a significant determinant of poverty and that female headed households were worse off than their male counterparts. This result is equally consistent with UNDP (2004) that 70 percent of the world's poorest people are women.

Table 6: Estimated poverty functions of the innovation adopters and non-adopters

Parameters	Innovation adopters		Non-adopters		Pooled		Pooled D	
	Coeff	t-ratio	Coeff	t-ratio	Coeff	t-ratio	Coeff	t-ratio
Constant	3.522	3.79***	2.75	3.84***	8.717	9.60***	9.994	7.61***
Sex	0.5977	2.88***	2.158	1.81*	0.081	5.41***	0.048	4.03***
Household size	-1.325	-2.98***	0.294	0.77	0.349	1.30	1.222	1.04
Age	0.069	0.47	0.003	1.11	0.238	1.13	0.101	1.45
Education	1.276	3.81***	0.664	3.25***	0.064	4.26***	0.026	3.51***
Assets	-0.203	-1.09	0.119	1.21	0.049	0.82	-0.066	-094
Income	0.421	4.10***	0.247	2.40**	0.384	5.65***	0996	2.83***
Dummy							1.069	5.72***
R^2		0.7382		0.6969		0.6353		0.6567
Adj R^2		0.6567		0.6523		0.5627		0.6021
F ratio		7.97***		4.05***		8.97***		10.99***

Source: Survey data, 2011
***, **, and * = significant at 1%, 5% and 10% levels respectively.

Household size was significant at 1% and negatively related to poverty status of the innovation adopters. This suggests that larger households are more likely to be poorer, which is consistent with economic theory. This could result when most of the household members are not working or are made up of the young and the elderly and resources are channeled towards their education and care. Ukoha *et al.* (2007) and Etim *et al*. (2011) noted that the larger the household size, the more difficult it may be for the household to meet the basic requirements such as education for children, proper nutrition and adequate housing, all of which tend to reinforce poverty in households that fail to cope with them.

Education was positive and significant at 1% for all the households. This means that as the households acquire more education, their rise out of poverty increases. This conforms to *a priori* expectations and the reports from Iheke (2010) and Etim *et al*. (2011). Education has a positive relationship with adoption of innovation, thereby improving efficiency efficiency and productivity. This leads to increased income with a concomitant increase in welfare (Nwaru 2004; Iheke 2010);

Household income was significant and positively related to household poverty status for both household groups, implying that as household income increases, household the rise out of poverty increases. This is consistent with *a priori* expectations and the Keynesian consumption function and the permanent income hypothesis of Friedman which posit a positive relationship between welfare and income. According to the permanent income hypothesis, which distinguishes between transitory and permanent components of income, households will spend mainly the permanent income while the transitory income is channeled into savings with marginal propensity to save from the income approaching unity. This agrees with Etim *et al*. (2011), Ukoha *et al.* (2007), Avery and Kannickel (1991) and Koskela and Viren (1982). Policies that remove constraints in agricultural production and increase income will improve welfare. Intervention in real terms in key areas of agricultural production, where farmers need assistance both collectively and individually to overcome constraints in production through appropriate policies, are therefore needed.

The result of the pooled data with a dummy representing household type was significant at 1% and positive. This implies that the innovation adopters have higher welfare than their counterparts, the non-adopters. This might be as a result of the multiplier effect of innovation adoption on output, income and investment.

Tests for structural shift in poverty function and differences in status

The results of the statistical tests for structural shift in poverty function and differences in welfare were summarized and presented in Table 7. The calculated Chow's F statistic for poverty effect was significant at 1%. The result confirms that there is significant difference between the poverty functions of adopters and non-adopters. In other words, the households that adopted innovations are associated with structural modifications of their poverty parameters, implying that the poverty functions of the households differ. The result of the test for homogeneity of slopes in the poverty functions of the farm households shows that the calculated Chow's F statistic was statistically significant at 1%. The result confirms heterogeneity of slopes or factor biased welfare functions.

Table 7: Tests for difference in poverty

Nature of analysis/Household type	Error sum of squares	Degrees of freedom	Calculated F
Tests for poverty effects			
Innovation adopters	14.195	49	
Non- adopters	12.327	57	
Pooled data	71.055	113	27.105***
Tests for homogeneity of slope			
Innovation adopters	14.195	49	
Non- adopters	12.327	57	
Pooled data with dummy	63.987	112	22.602***
Test for differences in intercept			
Pooled data	71.055	113	
Pooled data with dummy	63.987	112	12.372***

Source: Survey data, 2011. *** = significant at .01

The calculated Chow's F statistic for the test for differences in intercept is significant at 1%. This result confirmed heterogeneity of intercepts for the adopters and non-adopters and livelihood/welfare advantage for adopters derivable from the use of improved varieties and technologies. This confirms the result of the pooled data with dummy variable representing household type and thus reveals that innovation adopters have superior livelihoods relative to the non-adopters.

Conclusion

This study revealed that innovation adoption is key to increasing farm productivity and reduction in poverty level of rural farm households. It has significant and positive impact on farm productivity and innovation adopters have improved livelihood or better welfare than non-adopters. In order to increase farm productivity and reduce poverty among farm households, policies that would encourage them to embrace or step up adoption of agricultural innovations should be put in place. This should involve educating and enlightening the farm households. In this respect, agricultural extension services should be strengthened to provide the informal training that helps to unlock the natural talents and inherent enterprising qualities of the farm households, enhancing their ability to understand and evaluate new production techniques/innovations leading to increased farm productivity and incomes with concomitant reduction in poverty. On a broader perspective, to acheive sustainable growth in agricultural productivity and reduction in poverty, the country should invest in development of new innovation. Such innovative approaches should entail country-led, evidence-based strategies; greater investment in agriculture and social protection; development of technologies that address the challenges facing agriculture's contribution to food security; institutions that improve both coordination among smallholders along the supply chain and access to food stock during food security emergencies; and the dynamic involvement of new players. The development community should encourage the generation of innovations at the local level, accompanied by a framework for evaluating experiments and a political and legal space to transform the lessons learned into large-scale initiatives to reduce hunger and poverty.

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