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Abstract

The main purpose of the paper was to determine how farmers' social-economic characteristics affect adoption of agriculture research findings. Further, the study established effect of Agricultural Research Findings on Farming Productivity in Kenya. The study was informed by innovation diffusion theory. A multistage sampling technique was used to select sites and draw sample of farmers for the study. Findings from Heckman two-stage selection model showed that farmers' gender, age and income have a positive and significant influence on the adoption of agricultural research findings. Moreover, the adoption of agricultural research findings results in improved farming productivity. However, farmers' education exhibited no significant effect on the adoption of agricultural research findings. It could be that the farmers in the study area are within the same level of education hence no influence on the adoption of research findings.

Keywords: *Agricultural Research Findings, Farming Productivity, Social-Economic Characteristics, Income, Age, Education, Gender*

1.1 Introduction

The purpose of any research is to generate new knowledge, ideas and/or technologies, and to contribute to existing knowledge. It is important for researchers that the knowledge they create through their research work is utilized and has some impact on practice. Agricultural research not only provides information for policy makers and funding agencies, it also provides new and improved research- induced technology and farming practices to farmers. Sustainable competitive advantage in this day and era depends less on who has the information and increasingly on those able to make the best use of that information.

Farmers, on the other hand, need to know how to increase their yield; how to use new techniques and how to operate in dynamic markets and credit situations. Information from research findings on agricultural practices provide research-induced technology, innovations and improved farming methods, that can meet the farmers needs. This information, if effectively communicated to the farmers, can enhance the adoption of improved farming practices, and help farmers improve their productivity and incomes (Lucky & Achebe, 2013). The potentials of agricultural information to farmers have been reported by Vidanapathirana (2012) for him, agricultural information within the hands of the farmers means empowerment through control over their resources and decision-making processes.

While efforts to modernize and increase agricultural productivity requires many inputs such as supplies, market services, technologies and equipment's, this study views information as essential factor in agricultural advancement. In their review, Sani et al, (2014) identified agricultural information to be mainly generated from universities and research institutes, and the purpose is to provide farmers with information on best practices. According to them, research findings mainly dealt with, but not limited to, new crops varieties and their requirements, climate, weather, drought and water stress periods, commodity prices and price control, sale of agricultural products, food quality and safety as well as labeling information. They argued that farmers needed to have access to such information in order to improve their agricultural production.

Despite the great importance and availability of research findings to farmers, the adoption of the same is very low. Makau Nzuma (2011) in his study noted that the major challenge facing the Tea Research Foundation of Kenya (TRFK) was how to increase the adoption of improved technologies to close the gap between research and actual farm yields. Lawal and Oluyole (2008) also observed that majority of the cocoa farmers in Nigeria did not adopt technologies developed by the Cocoa Research Institute of Nigeria (CRIN)

Developing the agricultural sector is vital towards poverty reduction in developing countries and also in food production and global food security. Unfortunately information generated from research on best farming practices does not reach the rural farmers on time; sometimes, it does not get to them at all (Lucky & Achebe, 2013). Majority of Kenyan farmers are small scale farmers using traditional methods to grow complex mixture of crops (Muya *et al.*, 2010). The farmers' production levels are below optimum, not because they are small, but because they have limited access to and ways to convey valuable information to them in other to improve their productivity (Lucky & Achebe, 2013). Dissemination and adoption of agricultural research findings remain a big challenge; it creates the question as to what the institutions of research and higher learning and other information professionals, doing to ensure agriculture research findings are accessed and utilized by their beneficiaries.

This study is intended to provide a knowledge base for strengthening the ways in which agricultural research results can be accessed and used by those who need them. The ultimate purpose of agriculture research is to be of use, leading either to changes in current practice or to confirmation of it. However, in spite of the sophistication and magnitude of agricultural research, and in spite of almost thirty years of federally sponsored dissemination efforts, adoption of this valuable resource is low.

2.1 Theoretical Framework

The innovation diffusion theory has been popularized in Rogers's book, *Diffusion of Innovations*, 5^{th} Edition, (2003). Diffusion of innovations is a theory that seeks to explain how new technologies and innovations are adopted and spread through society. It explain the how, the why, and the rate of adoption.. This theory has been developed through decades of study of the diffusion of innovations in fields as varied as agriculture, technology, and substance abuse prevention (Rogers, 1995, 2002).

The diffusion theory explains five characteristics of innovations that influence an individual's decision to adopt or reject an innovation. The first characteristic is the perceived relative advantage. Rogers argued that the rate of adoption of any innovation is associated with the perceived advantage that the innovation will give the user. Therefore, farmers will adopt recommendations from research findings if they are convinced that the methods are superior and more productive than what they were using all along. The second characteristic is compatibility. The level which an innovation or a technology can be easily absorbed into an existing system determines whether or not the individual will accept or reject the innovation. How readily can farmers assimilate evidence- based procedures into existing practice? The more difficult it is, the less readily changes will be accepted. Thirdly, adoption relates to innovation complexity. If the innovation is perceived as complicated or difficult to use, an individual is unlikely to adopt it. The fourth characteristic is triability. This explains how easily an innovation may be experimented. If a user is able to test an innovation, the individual will be more likely to adopt it; similarly, if the innovation can be gradually implemented in small steps and stages, then it may be more readily accepted. Finally, observability also determines the willingness of adoption. An innovation is more likely to be adopted if its presence is observable. Therefore, if the adoption of research-based practices by farmers can visibly change what they say and do in practice, then the practices was taken up more easily.

There are a number of studies that used the Innovation Diffusion Theory to explain the adoption of new technologies or innovations. The model has been widely acknowledged as making a significant contribution to understanding of the dissemination of new ideas and has attracted considerable interest in the context of research utilization (Kanefsky, 2001; Nutley and Davies, 2000).

3.1 Material and Methods

The study used a both descriptive survey and explanatory research design. Descriptive research design will give a detailed and accurate description of how research information is disseminated, and how farmers are adopting this information. The study targeted farmers, research and education institutions, and librarians. A multistage sampling technique was used to select sites and draw sample of farmers for the study. Purposive sampling was applied on the education and research institutions and the libraries. The study used structured questionnaires to collect data. The questionnaires were administered to the sampled farmers, and were used for collection of primary data for analysis.

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4.1 Data Analysis Techniques

Once the questionnaires were collected by the researchers, they were coded and fed into the statistical software (i.e SAS and STATA) and analyzed. Initially screening of data will be done using sort functions. Data was based on the objectives and research hypothesis of the study. Quantitative data collected was analyzed using descriptive statistical techniques which were frequencies, mean, standard deviation and inferential statistics such as Correlation and regression analyses. The correlation analysis was used to establish the degree of relationship between independent variables and dependent variable. A regression analysis was used to estimate the effect of social-economics on adoption of agricultural research findings and their effect on farming productivity in Kenya.

Analytical model

To determine the effect of social-economics on adoption of agricultural research findings and Their Effect on Farming Productivity in Kenya, the Heckman two-stage selection model was used. The decision to either adopt or not and level of productivity are dependent variables and were estimated independently. Heckman two-step procedure was identified as an appropriate model for such independent estimation. Heckman two-step model involves estimation of two equations: First, is whether a household have adopted agricultural research findings or, and the second is the extent to which adoption of research findings has effected farming productivity (proportion of farm output). The proportion of farm output was conditional on the decision to adopt agricultural research findings. Heckman procedure is a relatively simple procedure for correcting sample selection bias with the popular usage of (Hoffman & Kassouf, 2005).

The model consists of two steps; firstly, selection equation was estimated using a probit model and secondly, an outcome equation was estimated using OLS regression. A Probit model predicts the probability of whether an individual household adopted or not as shown.

$$pr(Z_i = 1|w_i\alpha) = \phi(h(w_i\alpha)) + \varepsilon_i \quad \text{.......} \quad 1$$

Where $Z_i$is an indicator variable equal to unity for small-scale grain farmers that participate in the market, $\phi$is the standard normal cumulative distribution function, $w_i\alpha$ais the vector of effect of social-economic factors on decision to adopt or not to adopt, α is the vector of coefficients to be estimated, and$\varepsilon_i$is the error term assumed to be distributed normally with a mean of zero and a variance σ^2. The variable $Z_i$takes the value of 1 if the marginal utility the household i get from adopting is greater than zero, and zero otherwise. This is shown as follows

$$Z_i^* = w_i\alpha + u_i \quad \text{.......} \quad 2$$

Whereu_i is the latent level of utility the farmers get adopting agriculture research findings, u_i~ N (0, 1) and,

$$Z_i = 1 if Z_i^* > 0 \quad \text{.......} \quad 3$$

$$Z_i = 1 if Z_i^* \leq 0 \quad \text{.......} \quad 4$$

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In the second step, an additional regressor in the sales equation was included to correct for potential selection bias. This regressor is Inverse Mills Ratio (IMR). The IMR is computed as:

$$\frac{\varphi(h(w_i\tilde{\partial}))}{\varphi(w_i\tilde{\partial})} \quad \ldots\ldots 5$$

$$E = Y_i \mid Z = 1 = f(x_i, \beta) + \lambda \frac{\varphi(h(w_i\tilde{\partial}))}{\varphi(w_i\tilde{\partial})} \quad \ldots\ldots 6$$

Where E is the expectation operator, Y is the (continuous) proportion of farm output sold, x is a vector of independent variable affecting the quantity of farm output, and β is the vector of the corresponding coefficients to be estimated. Therefore, Yi can be expressed as follows:

$$Y_i^* = \beta' x_i + \gamma\lambda_i + u_i \ldots\ldots 7$$

Y_i^* is only observed for those grain farmers who participates in the collective marketing. Where ~N (0, σ_u). (Z_i = 1), in which case Yi= Y_i^* the model can thus be estimated as follows; in the first step of deciding whether to adopt agriculture research or not. This can be specified as:

$$P_{(0,1)} = \beta_0 X_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + e \ldots\ldots 8$$

Where participation is denoted by 1 and non- participation is denoted by 0, β_0 is a constant, $\beta_{1 \ldots n}$ are parameters to be estimated X_{is} are vector of explanatory variables. The Second step which involves a decision on the extent of adopt agriculture research is estimated by use of an OLS as follows;

$$Y = \beta_0 X_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + e \ldots\ldots 9$$

Where Y denotes the proportion of grain sales, β_0 is a constant, $\beta_{1 \ldots n}$ are parameters to be X_{is} estimated are vector of explanatory variables.

Heckman (1979) proposed a two-step procedure which only involves the estimation of a standard probit and a linear regression model. The two equations for the two steps are specified as follows:

Step 1. (Selection equation)

$$P_i(0,1) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon \ldots\ldots 10$$

$$P_i(0,1) = \beta_0 + \beta_0 + \beta_1 G_1 + \beta_2 E_2 + \beta_3 A_3 + \beta_4 I_4 + \varepsilon \ldots\ldots 11$$

Step 2. (Outcome equation)

$$proportion\ of\ grain\ sales/extent\ of partipation\ (Y)_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon \ldots\ldots 12$$

$$Y_i = \beta_0 + \beta_1 G_1 + \beta_2 E_2 + \beta_3 A_3 + \beta_4 I_4 + \varepsilon \ldots\ldots 13$$

Where;
Y = adoption of technologies
α= alpha coefficient, G = Gender, E= Education, A= Age, I = Income ε = error term

Findings

Sample characteristics

Table 1 show the inherent characteristics of the farmer involved in the study. The data shows that farmers had an average age of 43.36 years with minimum age of 27 years with a maximum age of 70. The most educated farmer had 19 years of education, with a minimum of 1 but on average they had mean years of education at 10 years. During the study, there a minimum of 1 individual in the household and a maximum of 13 but on average there were 6 individuals in the household. This indicates that farming in the region is usually undertaken by individuals over 43 years of age with secondary level of education.

Table 1 Demographic statistic of the farmer

	N	Min	Max	Mean	Std. Deviation
Age of the farmer	116	27.00	70.00	43.36	8.55
Years of education attained	116	1.00	19.00	10.01	3.27
Number of household members	116	1.00	13.00	5.85	2.17

Source: Research data (2018)

Correlation statistics

Pearson Correlations results in table 2 shows the relationship between gender, education, age, income, adoption of technologies and productivity. Pearson correlation results in table 2 showed that adoption of technologies positively related with productivity with a Pearson Correlation coefficient of r= 0.645 which is significant at $p < 0.01$. The output also shows that gender is positively related with productivity, with a coefficient of r = 0.670 which is also significant at p< 0.01. Additionally, age was also positively related with productivity, with a coefficient of r = 0.698 which is significant at p< 0.01. Furthermore, income positively related with productivity with a Pearson Correlation coefficient of r= 0.579 which is significant at $p < 0.01$. However, there was no correlation between education of the farmer and productivity.

Table 2 Correlation statistics

	Productivity	**Adoption of technologies**	**Gender**	**Education**	**Age**	**Income**
Productivity	1					
Adoption of technologies	.645**	1				
	0.00					
Gender	.670**	.564**	1			
	0	0				
Education	.115	.540**	.605**	1		
	0.592	0	0			
Age	.698**	.447**	.696**	.691**	1	
	0	0	0	0		
Income	.579**	.755**	.541**	.499**	.301**	1
	0	0	0	0	0	

** Correlation is significant at the 0.01 level (2-tailed).

Heckman Selection model

The dependent variables assessed were social economic characteristics of farmer and the level of adoption of agricultural research findings and farming productivity. The probit regression model is most often estimated using the standard maximum likelihood procedure within the Heckman selection model. The findings were summarized and presented in Table 3.

Table 3: Probit regression model estimation

Probit model with sample selection	**Number of obs = 103**
(regression model with sample selection) Censored obs = 0	
Uncensored obs = 103	
Wald $\chi^2(3) = 2.07$	
Log pseudo likelihood = 58.8457 Prob > χ^2 = 0.0490	

Table 4: Estimates of coefficients

	Coefficient	**Std. Err.**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Adoption Of Agriculture Research Findings						
Constant	1.08362	0.0620535	17.46	0.000	0.9619976	1.205243
Farmer Gender	0.796117	0.0209325	-0.94	0.034	-0..0606386	0.0214153
Farmers Education	-0.033236	0.0072216	-4.60	0.102	-0..0473905	-0..019082
Farmers age	0.507314	0.0005093	-1.44	0.015	-0..0017296	0.0002667
Farmers income	0.0294313	0.003864	7.6206	0.003	0.021858	0.0370047
Farming productivity						
Adoption Of Agriculture Research Findings	0.1168095	0.0209772	5.57	0.041	0.0756949	0.1579241
/athrho	-13.39028	-0.49073	-9.97	0.000	-0..5871836	-0..394273
/lnsigma	-1.990256	0.3381228	-5.89	0.000	-2.652964	-1.327548
Rho	-.4547943	0039337			-0..587867	-0..3850581
Wald test of indep. eqns. (rho = 0): χ^2 (1) = 99.43, Prob> χ^2 = 0.0300						

The HeckmanHeckman selection model is interpreted similar to the normal regression model Wald χ^2 (3) = 2.07, p = 0.0490 indicates that the researcher model is statistically significant in explaining the adoption of agricultural research findings. Furthermore, the Wald test of independence was used to assess the significance of each explanatory variable in explaining the variation in the response variable. The output revealed χ^2 (1) = 99.43, p-value = 0.030 which indicated that within the estimated model, each explanatory variable is independent in terms of their influence on the response variable.

In the estimation of the model coefficients, it is important to indicate that the estimated coefficients do not quantify the influence of the explanatory variables on the probability that the response variable takes on the value one and that the estimated coefficients are parameters of the latent model. From the findings in Table 4, it was shown that in relation to the response variable adoption of agriculture research findings, farmers' education (-0.033236, p-value = 0.102) had no statistically significant effect on the adoption of agricultural research findings. The study suggests that irrespective of the level of education of the farmer, it has no influence on whether they adopt agricultural research findings or not.

Furthermore, the findings revealed that farmers' gender had a positive and significant influence on the adoption of agricultural research findings, 0.796117, p-value = 0.034. This means that with each unit increase in gender, there is a 0.79 probability of increased adoption of agricultural research findings. Reasonable attention has been paid to the effect of gender on the adoption of inputs such as improved seed varieties and chemical fertilizer. Particularly, Doss and Morris (2001) found no significant differences in rates of modern maize varieties adoption between male and female farmers. Similarly, Bourdillon et al. (2002) and Chirwa (2005) found no gender differences in the adoption of improved seed in Zimbabwe and Malawi, respectively. There was however lack of evidence on the influence of gender on the adoption of agricultural research findings. The study therefore fills a gap in the literature regarding adoption of agricultural research findings.

Additionally, the findings indicated that farmers' age has a positive and significant influence on the adoption of agricultural research findings, 0.507314, p-value = 0.015. This clearly indicates that with each unit increase in farmers' age, there would be 0.507 probability of increased adoption of agricultural research findings. The farmers in the study area had an average age of 43 years. The oldest farmer was 70 years and the youngest was 27 years. The findings suggest that younger farmers are more receptive to the adoption of research results and technologies.

Also, the findings showed that farmers' income has a positive and significant influence on the adoption of agricultural research findings, 0.0294313, p-value = 0.003. This means that for each unit increase in farmers' income, there would be a 0.029 increased probability of adoption of agricultural research findings. These findings show that higher farmer income enables farmers to invest more in farming by adopting agricultural research findings. The reason for this is that there is more cash available to access major farm inputs such as fertilizers, adopt improved seed technologies and improved farming techniques.

Finally, the findings indicated that the adoption of agricultural research findings has a positive influence on the farming productivity, 0.1168095, p-value = 0.041. This indicates that with each unit increase in the adoption of agricultural research findings, there would be 0.116 increased probability of farming productivity. The implication is that the adoption of agricultural research findings is beneficial to the farmer in that farm productivity increases.

The **rho = estimate of *independent equation* indicates the correlation coefficient between error terms. This indicates that the equation has a significant positive correlation.**

5.1 Conclusion and Recommendation

There is overwhelming evidence from the study showing that farmers' gender, age and income have a positive and significant influence on the adoption of agricultural research findings. Moreover, the adoption of agricultural research findings results in improved farming productivity. However, farmers' education exhibited no significant effect on the adoption of agricultural research findings. It could be that the farmers in the study area are within the same level of education hence no influence on the adoption of research findings.

Furthermore, gender significantly influenced the adoption of agricultural research findings meaning that participation of both male and female households in farming increases the probability of adopting agricultural research findings. As well, the farmers' age had a positive influence on the adoption of agricultural research findings. The farmers in the study area were slightly younger (average age of 43 years) meaning they were more receptive and ready to adopt new agricultural research findings. On the other hand, farmers' income enabled farmers to access improved farming technologies that are fruits of agricultural research findings. As such, farmers' income positively influenced the adoption of agricultural research findings.

Basing on the observed findings, it is utmost necessary to have better educated farmers since they are more likely to adopt agricultural research findings. For this to happen, there is need to involve farmers so that their problems can be solved by research. For instance, education programmes can be introduced for farmers in form of extension packages. This way, research output will not be confined to the shelves of researchers. In such a manner, the problems that are focused on will be the ones that emanated from the farmers. Consequently, the interests of the farmers will be put into account.

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