AGRICULTURAL TECHNOLOGY ADOPTION AND PRODUCTIVITY AMONG SMALL SCALE FARMERS[1]

Adeyemi A. Ogundipe[1], Ogunniyi Adebayo[2], Abiola J. Asaleye[3]*

[1]Department of Economics and Development Studies, Covenant University, Ogun State, Nigeria, ade.ogundipe@covenantuniversity.edu.ng
[2]Department of Agricultural Economics, University of Ibadan, Nigeria.
[3]Department of Economics, Landmark University, Nigeria, email: asaleye.abiola@lmu.edu.ng, asaleyebiola@yahoo.com
*Corresponding Author

Abstract

The study assesses the role of technological adoption on the productivity of small scale farmers in Nigeria. The data used were extracted survey database of International Institute of Tropical Agriculture (IITA). The adoption of improved cassava variety has positive effect on farmers' productivity and poverty reduction. The Average Treatment Effect on the Treated (ATT) for productivity increased by 70 percent among ICVs farmers. Income was also higher among the adopters than the non- adopters by ₦43463.77. In the same vein, the income of the adopters increased by 17%. Furthermore, adopters of ICVs have the probability of reducing poverty headcount by 20%. The results suggest that improved agricultural innovation adoption can play a key role in strengthening and impacting agricultural productivity of smallholder farmers for increased income generation and food security.

Keywords: Small Scale farming, Agricultural productivity, Technological Adoption Nigeria

JEL Classification: B21 I32 Q12 Q16

1. INTRODUCTION

In Nigeria, agriculture is the source of food for the populace as well as raw materials for the agro-industries and accounts for 33 percent ofthe Gross Domestic Product (GDP). The sector employs nearly one-third of labor force and provides livelihood means to the rural for the rural population (FMARD, 2006).Nigeria is an agrarian society with about 70% of her population (approximately 140 million) participating in agricultural production (Ogundipe et al., 2019; NBS, 2006).

On the overall, improved agriculture technologies adoption is now recognized as a one of the necessary

[1] The paper is an abridged version of a recently concluded elaborate study titled "Small-scale farming, Agricultural Productivity and Poverty Reduction in Nigeria: The Enabling Role of Agricultural Technology Adoption" Published in the Journal of Agriculture and Ecology Research International 19(1): 1-5

conditions in the attainment of increase agricultural productivity, attainment of food security and overall poverty reduction ravaging many developing countries. Despite the numerous improved cassava varieties that have been released and, adopted by the farmers coupled with the fact that the new varieties have been reported to have a higher yield of about 16 tones/ha compared with the traditional varieties with only 10 tones/ha (Abdoulayeet al.,2014), the productivity of cassava is expected to have increased over the years, with a spillover poverty reduction effect among the rural smallholder cassava farmers. Therefore, the pertinent research questions that needto be answered are:

1. How do socio-economic and demographic characteristics of the farmers influence adoption of improved cassava varieties in the study area?
2. How does the computed poverty indices for the adopters lower than the non-adopter of improved cassava varieties?
3. What is the impact of adoption of improved cassava varieties on productivity and povertyreduction?

Therefore, in order to provide answers to the above questions, this study carried out an empirical assessment of the impact of improved cassava varieties adoption on productivity and poverty reduction among the cassava-based farming households in two (Oyo and Osun) dominant cassava producing States in Nigeria. Specifically, we estimated and compare the poverty indices among the adopters and non-adopters of improved cassava varieties in the study area and empirically determine the impact of adoption of improved cassava varieties on productivity and reduction of poverty among the rural farmers in the study area.

2. ICVS ADOPTION AND IMPACT ON PRODUCTIVITY AND POVERTY STATUS OF ADOPTERS

In order to investigate the impact of adoption of improved varieties of cassava (ICVs) on poverty status of the adopters, the study adopted a multivariate analysis. In extracting the impact of ICVs from other interfering factors, counterfactual outcome is required and has to be established, this is to avert selection bias. As specified in literature, the establishment of a counterfactual outcome represents the status of the farmers if ICVs were not introduced to the farmers (Heckman and smith 1999). Zaini (2000) confirmed that these problems become more complex when participants self select into the project. A control group was used due to the difficulty in setting up a counterfactual situation. The control group was made up of no adopters of ICVs. To allow for selection bias in the assessment of the poverty impact of ICVs adoption, the identification variable approach following the Heckman two stage procedures was adopted to analyze the data. The unobservable factor which may create bias in the outcome on poverty due to adoption of ICVs is referred to as ‘selection bias’. An appropriate and acceptable identification variable for this two step procedure needs to be identified for the analysis. The identified variable needs to influence adoption but not poverty. Again if an acceptable identification variable was found, the results from the procedure can be sensitive to the choice of this variable. . Because of this limitation the results from the analysis has to be checked for ‘robustness’ (Zaman, 2000).

Two stages are involved in the Heckman procedure, first is the estimation of the adoption process and second is the estimation of the poverty outcome. The Heckman two-step model is specified as follows; the first step (selection equation) illustratingwhether farmer adopt or planted ICVs or not is empirically specified as:

$$\begin{aligned} adoption = {} & \alpha_0 + \alpha_1 extensioncontact + \alpha_2 instituterel + \alpha_3 hhsize + \alpha_4 lognonprodcasset + \alpha_5 occup + \alpha_6 age \\ & + \alpha_7 eduyrs + \alpha_8 ttnonfarmincc + \alpha_9 gender2 + \alpha_{10} landlac + \alpha_{11} logprodasset \\ & + \alpha_{12} rentedland + \alpha_{13} totalcosthlabour + \alpha_{14} owntelevision + \alpha_{15} ownmobile \\ & + \alpha_{16} creditaccess + \alpha_{17} ownradio + \varepsilon_i \end{aligned}$$

The second step (outcome equation), which assesses the effect of market participationon the welfare of households (consumption expenditure per capita), is estimated empirically using OLS as follows:

$$\begin{aligned} yield = {} & \beta_0 + \beta_1 hhsize + \beta_2 lognonprodcasset + \beta_3 occup + \beta_4 age + \beta_5 eduyrs + \beta_6 ttnonfarmincc \\ & + \beta_7 gender2 + \beta_8 landlac + \beta_9 logprodasset + \beta_{10} rentedland + \beta_{11} totalcosthlabour \\ & + \beta_{12} owntelevision + \beta_{13} ownmobile + \beta_{14} creditaccess + \beta_{15} ownradio + u_i \end{aligned}$$

3. DATA AND SAMPLING FRAMEWORK

The study was conducted in southwest Nigeria. The data for this study originated from a survey conducted by IITA in 2011. Among the six states that made up the Southwest geopolitical zone was chosen Fives states. But this study made use of data of two states out of the five states surveyed because they are the largest producers of cassava among the six states of southwest identified during the survey.These states are

Osun and Oyo states. A three-stage stratified random sampling procedure was used whereby states were used as strata to improve sampling efficiency and account for possible major differences in the adoption of improved cassava varieties across the states. The primary sampling unit was the Local Government Areas (LGAs) while Enumerationareas – definedas a cluster of housing units were used as the secondary sampling units and the final sampling units were the households.

The Local Government Areas (LGAs) were selected from each state based on the probability proportional to size, where size is measured interms of the number of Enumeration areas (EAs). The EAs that constituted the sampling frame were obtainedfrom the Nigerian Bureau of Statistics which uses the 2003/2004 master sampling frame of the National Integrated Survey of Households. The approach of using the EAs as the sampling unit is beneficial because each EA is approximately the same size. This will enable all farmers have an equal probability of being included. From each LGA, four EAs were selected at random from the sampling frame classified as rural or semi-urban, producing a total of 80EAs. Finally, households' list was formulated for selected EAs and a sample of 10 farming households was chosen at random in each of the sampled EAs giving a total of at least 446 households. Questionnaires were administered at community and household level by trained enumerators with a senior agricultural economics in the field and the general supervision of IITA's economist.

The data that was gathered on the socio-economic characteristics of the respondents such as ageof household head, marital status, sex, family size, level of formal education, reasons for farming, land acquisition method, years of farming experience, farm size (in ha) and on adoption. Input and output data such as cassava output, cost of input, income from output, labour output in man days were collected. The data collection was majorly on the socio-economic characteristics of the cassava farmers and cassava production variables.

4. RESULTS AND DISCUSSION

4.1. Impact of Adoption on Productivity

Results in Table 6 indicate the ATT is obtained using Nearest Neighbor Matching (NNM) and Kernel Based Matching (KBM) algorithms. These results indicated that adoption of improved cassava variety has a robust positive and significant impact on cassava yield. Becerril and Abdulai (2007), Mendola (2006) obtained similar results. Results in Table 6 shows that, on average, the increase in cassava yield after adoption of improved variety (ATT) is about 70% using NNM and it is about 38% using the KBM which means the adoption of improved cassava variety has caused the yield of cassava farmers to increase.

4.2. Impact of Adoption of Improved Cassava Varieties on Farmers' Income

In the same vein, PSM was used to check for the impact of adoption on the farmers' income. The result of the analysis of the impact of adoption of improved cassava variety on income and poverty status between adopters and non-adopters of ICVs is shown in the Table.7, below. As it is evident from the table, the incidence of poverty was higher among non- adopters as income of adopters was higher than that of the non-adopters by N43463.77.

In addition, by adoption of improved cassava varieties there is income increase on the part of adopters by 30% using the NNM, while the KBM also revealed that the adopters' income increased by 17% compared to that of the non-adopters. This shows that, irrespective of the matching method adopted, this study has been able to establish that improved cassava varieties had a positive impact on income of the farmers and therefore contributed to poverty reduction. This conforms to the finding of Souléïmane (2006).In the same vein, we found that the adoption of improved cassava varieties also have a significant poverty reducing effect of about 20% as shown in Table 15. Thus, adoption of improved cassava varieties did not only increase productivity, it also generates an increase in farmers' income with a significant reduction in the proportion of the farmers that were below the poverty line.

4.3. Impact of adoption of ICVs on poverty status of adopters

In order to evaluate the effect of adoption of ICVs on households' welfare a multivariate analysis was conducted using Heckman's two-stage model. The dependent variable of the adoption model was specified as binary which is equal to 1 if farmers adopt ICV and 0 otherwise. The second stage of the analysis in the Heckman's model (Table 7a&b) estimates the factors that determine the farmers' yield and also test for selection bias by inserting the lambda obtained from the first stage of the Heckman's model which is probit model. Contact with extension agent and relationship with institution were used as the identification variables. These variables are assumed to influence the probability of adoption of ICVs and not the farmers' yield.

In this context, yield was used as a proxy for productivity hitherto welfare. This means any variable that increases yield will definitely increase productivity and thereby increases the welfare of the family. In the first stage of the Heckman's model, the coefficients of occupation and non-production assets were positive and statistically significant. Farmer whose primary occupation is farming has higher probability of adopting improved cassava varieties than farmers whose primary occupation is not farming. In the same vein, there is positive relationship between adoption and total non-production asset. Farmers with higher non-production assets has higher rate of adoption. This could be traced to the fact that farmers who have other assets that can be used as capital are willing to venture into new business in order to increase their stream of income hence adopt new innovation on time than farmers without non-production asset

In the second stage of Heckamn's model analysis, the coefficient of total cost of labour and household size were positive and statistically significant which means higher labour increases the rate at which farm activities are performed and this in turn increases yield. The same process goes for household size, the larger the household size the higher the yield. This can be attributed to the fact that farm labor supply will increase due to large household size.Access to television and mobile phone has negative coefficients and this simply means yield and access to media are negatively related hence increase in access to television and radio leads to reduction in yield. This could mean that farmers spend useful time that they suppose to use for productive farming work in watching programs that are not educative on television and this has in a way reduce labor supply and will surely reduce productivity. But this result negates the findings of NaveedJehanet.al (2014) that says access to media increases productivity.Didier Alia (2013) was of the opinion that farmer's productivity increases when listening to informative and educative programs on the crop he cultivates rather than entertaining programs.The output of the diagnostic analysis revealed that the mill ratio also known as lambda is not statistically significant which implies that there is no problem of selection bias in the modelbeing used for estimation hence we revert to use linear regression to determine the impact of adoption on yield. From the regression analysis, the coefficients of total cost of labour and production assets are positive and statistically significant. Hence a unit increase in the amount expended on labor and production assets leads to 0.0002 and 0.164 increments in the yield of improved cassava variety respectively.

5. SUMMARY, CONCLUSION AND RECOMMENDATION

Improved cassava varieties were developed with the aim of contributing to poverty reduction andimproving food security through increased productivity of Cassava. This study provides an ex- post assessment of improved cassava varieties adoption on productivity, income and poverty reduction using a cross-sectional data collected in 2011 by IITA from randomly selected sample of 446 households in both Osun and Oyo state of Nigeria.Analysis of the socioeconomic variables of farm households revealed that the mean age was 52years which means it's the experienced and fairly old farmers that are engaged in cassava production in the study area. It was also shown that timely and adequate information on improved cassava variety through mass media has positive and significant effect on the adoption level of the farmers. This study reveals that the adopters are significantly different from the non-adopters in terms of observable characteristics such as: Age, income, output, farm size, household assets (farm and non-farm). The proportion of poor households is higher in Osun State (56%) than in Oyo State (48%). Non-adopters are poorer (56%) than the adopters (47%).

The result of the first stage of Heckman two stage model was showed that occupation of household head and non-production farm assets positively and significantly determine the adoption of improved cassava varieties in the study area.Farmer whose primary occupation is farming has higher probability of adopting improved cassava varieties than farmers whose primary occupation is not farming. Adoption of improved cassava varieties have positive and significant impact on productivity and farmers' income and thus capable of leading to a reduction in poverty. The result of the second stage of Heckman two-stage model also showed that the coefficient of total cost of labour and household size were positive and statistically significant and thus positively affect yield. The causal impact of improved cassava varieties adoption was estimated using PSM with two different matching methods to assess robustness of the results. This study however shows that whichever matching method is used, the adoption of improved cassava varieties has a positive and significant impact on productivity, income and overall reduction in the proportion of the households that are below the poverty line.

There are three main conclusions that can be drawn from the results of this study on the impact of improved cassava variety adoption on productivity and poverty reduction. First, the group of farm households that adopted has systematically different characteristics than the group of farm households that did not adopt when some key socio-economic and physical variables are compared. Second, both the propensity score matching and Heckman's two-stage model resultssuggest that adopters of improved cassava varieties have significantly higher income than non-adopters even after controlling for all confounding factors. Third, the

regression result revealed that any marginal increment intotal cost of labour and production assets will lead to yield increase and thereby reduce poverty. The results of all these three analysis carried out showed that adoption of improved cassava variety reduces povertysignificantly. The results from this study generally confirms the potential direct role of adoption of improved varieties on improving rural household welfare, as higher incomes from improved varieties leads to poverty reduction.

The analysis of the determinants of adoption shows house hold head occupation and non-production assets are key determinants for adoption. This implies the need for policy to strengthen government extension services in the rural areas to promote and create awareness about the existing improved cassava varieties since the major occupation in this study area is farming. Also, innovative cassava projects that could yield good profit on returns should be launched in the area as farmers are willing to try new business. The government and Non-Governmental Organizations (NGOs) will need to take the lead in technology promotion and dissemination at the early stages of technology initiation and in providinga conducive environment for effective participation of the rural farmers. Awareness campaigns for improved varieties and its availability at the right time (planting season) will accelerate and expand adoption.

ACKNOWLEDGEMENT

We thank Covenant University for providing a conducive ambient for research and defraying the cost of publishing this work.

REFERENCE LIST

Adekambi, S.A., Diagne, A., Simtowe, F. P., Biaou, G. (2009). The impact of agricultural technology adoption on poverty: The case of NERICA rice varieties in Benin. Paper presented at the International Association of Agriculture economists' 2009

Abdoulaye, T., Abass A., Maziya-Dixon, B., Tarawali, G. (2014). Awareness and adoption of improved Cassava varieties and processing technologies in Nigeria

Alia, D. Y., Nakelse, T., Diagne, A. (2013). Rural Media, agricultural technology adoption and productivity:evidences from small rice farmers in Burkina Faso. Paper presented at the 4th International conference of the Africa Association of Agricultural economists, September 22-25, 2013, Hammanet, Tunisia

Becerril, J. and Abdulai, A. (2009) The impact of improved maize varieties on poverty in Mexico: A propensity score marching approach. *World Development,* 38 (7), pp. 1024-1035.

Heckman, J, Ichimura, H., Smith, J. and Todd, P. (1998) Characterizing selection bias using experimental data. *Econometrica,* 66 (5), pp. 1017–1098.

Jehan, N., Aujla, K.M., Shahzad, M., Hussain, A., Zahoor, M., Khan, M. and Bilah, A. (2014). Use of mobile phones by farming community and its impact on vegetable productivity. Pakistan J. of agric, Res. Vol 27(1): 58-63

Mendola, M. (2006) Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. *Food Policy*, 32 (3), pp. 372–93.

National Bureau of Statistics (NBS). Nigeria, Abuja National Population Census (NPC) (2006).

National Bureau of Statistics Official Gazatte (FGP 71/52007/2,500(OL24) Abuja. URL http://www.nigerianstat.gov.ng

Ogundipe, A. A., Ogunniyi A., Olagunju, K., & Asaleye J. A. (2019). Povetry and Income Inequality in Rural Agarian Household of Southwestern Nigeria: The Gender Perspective. The Open Agriculture Journal 13: 51-57

Ogunniyi A., Oluseyi OK., Adeyemi O., Kabir SK., Philips F. (2017). Scaling up Agricultural Innovation for Inclusive Livelihood and Production Outcomes in Sub-saharan Africa.

The case of Nigeria.*African Development Review* 121-34

Zaman, H. (2000). Assessing the poverty and Vulnerability impact of Micro-credit in Bangladesh: A case study of BRAC. Available @ https://www.researchgate.net/publication/265433649

Zaini, A. (2000). Rural Development, employment, income and poverty in Lombok, Indonesia. PhD Thesis. Georg-August-Universitat.Gottingen