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ANALYSIS OF IMPROVED CASSAVA VARIETIES' CULTIVATION AND DOWNSIDE RISK EXPOSURE AMONG FARMERS IN ONDO STATE, NIGERIA

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Abstract

This study examined the impact of improved cassava varieties' cultivation and downside risk exposure among farmers in Ondo State, Nigeria. The multistage sampling procedure was employed to select 154 respondents for the study. The analytical tools employed are descriptive statistics and Endogenous Switching Regression (ESR) model. The empirical findings revealed that the respondents who were adopters and non-adopters were in their active ages, married, with some level of formal education and mainly male. The results of the Endogenous Switching Regression model revealed that years of formal education, extension agent visit, the quantity of herbicide used, quantity of hired labour, the quantity of fertilizer used and awareness of the importance of improved cassava varieties were positive and significant in determining the adoption of improved cassava varieties. Adoption of improved cassava varieties reduced the downside risk exposure (probability of crop failure) among farmers. Adoption of improved cassava varieties can reduce the downside risk exposure (likelihood of crop failure) among farmers. Therefore, the study recommended that extension agents should be supported by both government and non-governmental organizations to visit the farmers regularly and orientate them about inputs combination that can therefore, increase the farm output and reduce the probability of crop failure.

Key words**:** *improved cassava varieties, downside risk, crop failure, endogenous switching regression*

INTRODUCTION

Economic growth and development in sub-Saharan Africa cannot be appraised without reference to Agriculture as it plays an important role. It has engaged most of the labour force, provide the industries with raw materials and food commodities to the populace [10]. According to [1], Cassava (*Manihot esculenta*) serves as crucial food source for the population of sub- Saharan Africa and it is very vital in the welfare of farmer due to its ability to produce in average soil and survive drought. Farming system of Nigeria supports the cultivation of cassava as a food crop and Nigeria is the largest cassava producer in the world. Three times cassava output produced in Brazil, Ghana and Democratic Republic of Congo can be attributed to Nigeria making her to produce nineteen percent of the world cassava output [11].

[5] revealed that farm productivity can be raised and household poverty can be reduced through the adoption of agricultural technologies in developing economies. [19] identified with increase households' income and reduce poverty, increase households' food security, increase production and reduce various agricultural risks as part of the numerous reasons why improved cassava varieties (ICV) were developed. ICV, a product of improved technology plays a critical role in increasing agricultural productivity [24]. The rate at which this ICV is adopted is on the increase as identified by [5], translating to increase in annual income and annual consumption expenditure of farmers thus increasing welfare in Nigeria. Despite this adoption and production level, [20] posited that low yields characterize cassava production in Nigeria unlike other regions of the world where this crop is cultivated. Also, agriculture is known to be

very risky all over the world because of numerous reason which could be classified as controllable and uncontrollable factors. Production risk can be among the highly uncertain and potentially devastating resulting to uncertainty in consumption and profit of farmers [26].

Agricultural risks are common all over the world and they are strenuous to small scale farmers in developing countries [9]. According to [21], outcome of risks in agricultural production are strong in Africa where there is inconsistent rainfall, prevalence of pests and diseases outbreaks resulting into wide variations in crop and livestock yields.

There are various studies on impact of improved technologies on farming households' welfare (such as [5]. Also, there are well known literatures on farmers' attitude towards risk and few studies on the risks that the farmers might face in the adoption of such technology. With these in the literature, there is little or no information about downside risk exposure of farmers because of the agricultural technology especially among cassava farmers being one of the most exploited crop in this part of the world. Policy makers and donors agencies need information on these impacts to allocate resources to fruitful lines of research and to strengthen the role of agricultural research in fighting poverty, hunger, and malnutrition. International organizations and governments expect improved varieties to alleviate malnutrition and hunger, but to date; impact assessment studies have mainly been directed towards productivity and aggregate welfare measures. Hence, this study examined the improved cassava varieties cultivation and the downside risk exposures among farmers in Ondo State, Nigeria.

This paper contributes to the body of knowledge in these ways. This study has analysed the contribution of improved cassava varieties cultivation to welfare i.e. lower downside risk exposure (probability of crop failure) since it has not been exploited studies. It simultaneously estimate the determinants of adoption and impact of improved cassava varieties adoption on the downside risk exposure of the farmers as it account for both observable and unobservable factors efficiently, endogenous switching regression model approach [15] was used for downside risk exposure being a continuous outcome.

Agricultural Risk and Technology Adoption

The use of new technologies do comes with risk and uncertainty which could be seen in the distribution farmers' profits [13]. [17] argued that farmers are likely to come to any new technology with doubt, uncertainty, prejudices and preconceptions. Unless they are greenhorn farmers, they would have tested some new invention in the previous years and conclude it may not be true as claimed by the developers. Farmers are likely to be skeptical about methods which differs from what they are familiar and comfortable with. This could result to them holding an attitude that the people inventing new technology of system don't understand the realities of farming or at least of their farm.

MATERIALS AND METHODS

Study area

This study was carried out in Ondo State, southwest, Nigeria. There are three distinct ecological zones within the State; the mangrove forest to the south, the rain forest in the middle part and the derived savanna to the north. The State has 18 Local Government Areas (LGAs). The State lies within latitudes 50 45' and 80 15' N and longitudes 40 45' and 60 5' E. The land area is about 14,793,186 square kilometer with varying features like hills, lowland, rivers, creeks and lagoons [18]. The State has a fairly large population of about 3.4 million people suggesting a potential for high output. From the population records, 60.92 percent of the population lives in rural areas while the remaining 39.6 percent live in the urban areas [18]. The State enjoys luxuriant vegetation with vast rain forests in the southern part while the northern fringe in the mostly sub-savanna forest.

Data Source

Data for the study were obtained from the primary source. Primary data were collected with a structured questionnaire from cassava farmers in Ondo State. Some of the data collected include valuable information on households' composition and characteristics, area planted, output and yield.

Classification of Respondents as Adopters and Non-Adopters of Improved Cassava Varieties

In this study, farmers were classified as adopters if they have grown at least one of the prominent improved cassava varieties introduced for at least one season before year 2018 (the year the data for the study were collected) or still growing anyone in the study area and non-adopters otherwise.

Sampling and Sample Size

The multi-stage sampling procedure was used for the study. The first stage involved a purposive selection of four blocks which include Okitipupa, Ondo West, Akure North, and Akoko South-West of the four Agricultural Development Programme (ADP) zones based on the intensity of cassava farmers. The second stage was a random selection of two communities in each of the selected blocks. The last stage was a random selection of ten cassava producing households that adopted the selected improved cassava varieties and ten cassava producing households that planted none of the selected improved cassava varieties from each of the selected communities in Ondo State. 154 completed copies of the questionnaire comprising seventy-nine adopters and seventy-five non-adopters were analysed. Out of all the cassava farmers sampled, data from 154 cassava farmers were used for the analysis while 6 were discarded due to incomplete information supplied by the farmers.

Conceptual Framework

Improved Cassava Varieties Adoption Decision

The choice of farmers is assumed to be two possible outcomes of either to adopt ICV or otherwise, the adoption decision-making process and effect of the improved cassava varieties on downside risk exposure can be modeled in an optimization framework denoted by U_{iA} and U_{iN}, respectively. The net welfare of farmer i which is unobserved is represented by $P_i^* = U_{iC} - U_{iN}$. This is possible only when the decision status is known to the researcher, but the households' preferences like net are known to only the farmer. The net welfare from improved cassava varieties adoption can be expressed regarding a vector of household explanatory variables in a latent variable framework as:

$$P_i^* = X_i'\alpha + \varepsilon_i, \quad P_i = [P_i^* > 0] \qquad (1)$$

where:

P_i^* is a binary variable, with 1 for farmers who adopted the improved cassava varieties and 0 otherwise;

X includes all observable factors that influence improved cassava varieties adoption decision, such as household and farm level characteristics; $\propto$ is a vector of parameters to be estimated; $\mathcal{E}$ is the error term with mean zero, and variance σ_ε^2 capturing measurement errors and unobserved factors.

Farming Households' Impact Evaluation

This study investigates the impact of improved cassava varieties adoption on farming households' downside risk exposure. Given this vector of outcomes is a linear function of a vector of farm and household characteristics, the outcome variables can be expressed as

$$Y_h = Z_h'\beta + C_h\gamma + \mu_{h,} \qquad (2)$$

where:

Y_h represents a vector of outcome variables; Z_h is a vector of farm and households' characteristics (e.g., extension visit, age, education);

C_h as described is an indicator of household improved cassava varieties adoption status; μ_h is a random error term, and

β and γ are the vector of parameters to be estimated.

In impact evaluation, only observed attributes declared by the farmer in the survey are known to the researcher, but unobservable factors like innate technical, social networking, risk, and managerial abilities are known to only the farmer. Potential selection bias arises where the undeclared factors in the outcome influencing the selection. This implies the correlation coefficient of the error terms $\rho = corr\ (\varepsilon\ ,\ \mu\ ) = 0$, hence ordinary least squares (OLS) yield bias estimates. In a randomized control trial setting, this selection bias problem is addressed by randomly assigning individuals into treatment (adopters) and control (non-adopters) groups, so the only differentiating factor among adopters and non-adopters in the technology [7].

However, in a non-randomized experimental situation like the adoption of improved cassava varieties, adoption is not random and selection bias may occur. The PSM approach is commonly used in impact evaluation of technology on household welfare, in particular when self-selection occurs (e.g., [14]. According to [2] a major drawback of the PSM approach is that it only accounts for observable factors. To simultaneously estimate the determinants and impact of adoption, while accounting for both observable and unobservable factors efficiently, an Endogenous Switching Regression Model approach developed by [15] is employed. Therefore, the Endogenous Switching Regression is suitable for continuously expected welfare indices like downside risk exposure.

Analytical techniques

The objectives of this study were achieved with using several analytical methods. These include descriptive statistics, Endogenous switching regression model.

Endogenous switching regression model

Endogenous Switching Regression Model was used to examine the impact of improved cassava varieties adoption on downside risk exposure. In the ESR model framework, a two-stage estimation procedure is estimated simultaneously. The first stage involves estimating the adoption decision to determine the factors influencing adoption in equation (1). In the second stage, the impact of adoption on the outcome variables is specified for two regimes of adopters and non-adopters of the improved cassava varieties as:

Regime 1 (adopters):

$$Y_{hA} = Z'_{hA}\,\beta + \mu_{hA} \text{ If } P_h = 1, \qquad \text{(3a)}$$

Regime 0 (non-adopters):

$$Y_{hN} = Z'_{hN}\,\beta + \mu_{hN} \text{ If } P_h = 0, \qquad \text{(3b)}$$

where: Y_{hA} and Y_{hN} are outcome variables for adopters and non-adopters respectively; Z is a vector of households' endowments and farm-level characteristics; β is a vector of parameters to be estimated; μ is the error term. The structure of the ESR model allows for an overlap of X in Eq. (2) and Z of Eqns. (3a) and (3b). But for identification, at least one variable in X should not appear in Z, hence the selection equation is estimated using the same variables in the outcome equation besides at least an identifying instrument. A valid instrument is expected to influence adoption and not the outcome. To account for selection bias, the variables in Z in Eqs. (3a) and (3b) account for only observable factors. However, the ESR model can address selection bias due to unobservable factors within a framework of the omitted variable problem. Specifically, Heckman 1979 indicates that the inverse mills ratios or selectivity terms from the selection equation represented by λ_A for adopters and λ_N for non-adopters, and the covariance terms $\sigma_{A\varepsilon}, \sigma_{N\varepsilon}$ are plugged into (3a) and (3b) to obtain (4a) and (4b) and specified as:

$$Y_{hA} = Z'_{hA}\,\beta + \sigma_{A\varepsilon}\,\lambda_A + \vartheta_{hA} \text{ If } P_h = 1, \qquad \text{(4a)}$$

$$Y_{hN} = Z'_{hN}\,\beta + \sigma_{N\varepsilon}\,\lambda_N + \vartheta_{hN} \text{ If } P_h = 0, \qquad \text{(4b)}$$

where: the selectivity terms λ_A and λ_N correct for selection bias from unobservable factors and ϑ_A and ϑ_N are the error terms with conditional zero means.

[15] argued that a disadvantage of the two-stage approach is that it generates residuals that are heteroskedastic and cannot be used to obtain consistent standard errors without cumbersome adjustments. They then proposed a full information maximum likelihood approach, used in this study, as an efficient methodology to simultaneously estimate the outcome and selection equations. Therefore, the Endogenous Switching Regression model was used to examine the impact of adopting improved cassava varieties on downside risk exposure.

It is used where both observable and unobservable characteristics are accounted for, thus controlling for a 'hidden bias' which could arise when unobservable variables are not taken into account. Ignoring the endogeneity of the adoption of improved cassava varieties would cause biased estimated parameters. To address the endogeneity problem, this study used the Endogenous Switching Regression model, which accounts for the correlation in the unobserved characteristics in the decision to adopt the improved cassava varieties and continuous expected outcome i.e. downside risk exposure.

A valid instrument is expected to influence adoption and not the outcomes. In this study, a variable on farmer's awareness of the usefulness of improved cassava varieties is hypothesized to affect adoption decisions but not the outcome. This is considered valid and relevant instrument.

The impact of adopting the improved cassava varieties on downside risk exposure was examined by comparing the expected outcome of downside risk exposure of farmers who adopt with expected outcomes of the counterfactual hypothetical cases that did not adopt. The expected values of the outcome Y on adoption and non-adoption can be expressed as in Equations. (9a) and (9b):

Regime 1 (adopters):

$$E(Y_{hA}|P=1) = Z'X_{hA} - \sigma_{A\varepsilon}\lambda_A \quad (5a)$$

Regime 0 (non-adopters):

$$E(Y_{hN}|P=1) = Z'X_{hN} - \sigma_{N\varepsilon}\lambda_N \quad (5b)$$

A change in the outcome due to adoption termed the average treatment effect on the treated (ATT), is expressed in Eq. (10) as the difference in the expected outcomes from Eqs. (5a) and (5b) [20]:

$$ATT = E(Y_{hA}|P=1) - E(Y_{hN}|P=1)$$
$$\text{ATT} = Z(\beta_{hA} - \beta_{hN}) + \lambda_A(\sigma_{A\varepsilon} - \sigma_{N\varepsilon}) \quad (6)$$

where: E (Y_{hA} and Y_{hN}) are expected outcome variables for adopters and non-adopters respectively;

X_i is a vector of households' endowments and farm-level characteristics; Z is a vector of parameters to be estimated; λ is the inverse mills ratios; σ is the covariance of the error terms.

Thus, the independent (explanatory) variables used are as specified below:

X_1 = Age (years),
X_2 = Sex (1 if male 0 otherwise),
X_3 = Household Size (Number),
X_4 = Farming experience (years),
X_5 = Marital status (1 if married and 0 otherwise),
X_6 = Membership of association (1 if a member of farmers' association and 0 otherwise),
X_7 = Contact with Extension Agent (1 if yes),
X_8 = Years of formal education (years),
X_9 = Quantity of hired labour (man days)
X_{10} = Quantity of fertilizer used (kilograms)
X_{11} = Quantity of herbicide used (litres)
X_{12} = Awareness of the importance of ICV (1 if aware and 0 otherwise),
X_{13} = Farm Size (Number).

Estimation of downside risk exposure

For this study, the specification of the downside risk exposure follows, [6] flexible moment-based approach. The flexible moment-based approach used the first moment (mean), second moment (variance) and the third moment (skewness) of the production function to measure the impact of various inputs on yield and downside risk. The flexible moment-based approach considered skewness of output as a measurement of downside risk exposure.

The production is represented by the production function $y = g(x, v)$, where v is a vector of random variables reflecting uncontrollable factors affecting output (e.g., rainfall).

Consider the following econometric specification for $g(x, v)$:

$$g(x, v) = f_1(x, \beta_1) + u \quad (7)$$

where:

$f_1(x, \beta_1) \equiv E[g(x, v)]$ is the mean of $g(x, v)$, and $u \equiv g(x, v) - f_1(x, \beta_1)$ is a random variable with mean 0.

$$y = \beta_0 + X_i\beta_i + e \quad (8)$$

y = Cassava Yield

X_1 = Age (years),
X_2 = Years of formal education (years),
X_3 = Access to improved cassava cutting,
X_4 = Quantity of fertilizer used (kilogrammes),
X_5 = Household Size (Number),
X_6 = Total labour used (man days),
X_7 = Quantity of pesticide used (litres),
X_8 = Quantity of insecticide used (litres),
X_9 = Contact with Extension Agent (1 if yes),
u = error term

The higher moment of $g(x, v)$ are given by

$$E\{[g(x,v) - f_1(x, \beta_1)]^k \mid x\} = f_k(x, \beta_k) \quad (9)$$

For k = 2, 3,….. Equations (11) and (12) give the central moments of distributing $g(x, v)$, including the first moment (the mean) $f_1(x, \beta_1)$, the second central moment (the variance) $f_2(x, \beta_2) > 0$, and the third central moment (measuring skewness) $f_3(x, \beta_3)$. This flexibly represents the impacts of inputs x on distributing output under production uncertainty.

This study involves the estimation of the production function for cassava output. It relies on equations (11) and (12), where the dependent variable y is the cassava yield, with the mean $f_1(x, \beta_1)$, variance $f_2(x, \beta_2)$and skewness $f_3(x, \beta_3)$.

RESULTS AND DISCUSSIONS

This section presents the discussion and interpretation of results obtained from the analysis of data collected for this study.

Socio-economic Characteristics of Respondents

As shown in Table 1, the mean age of the respondents was 42.96 years and 43.70 years old respectively for adopters and non adopters. This is an indication that majority of the respondents were still within the economically active age. It also implied that the respondents were agile and active to withstand the rigours of farming. The results is in agreement with [22] who opined that for farmers to be productive in farm chores, they must be young and active in order to contribute meaningful labour input into all the stages of production for efficient output realization which in turn results in consumptive and income opportunities with proportional household welfare. Male farmers had the larger percentage of the sampled adopters and non adopters and this could be due to laborious nature of cassava production. The educational status of the respondents revealed that majority (93.7% and 88.0%) of the respondents who were adopters and non-adopters respectively had at least primary school education. It indicated that only 6.3% of the adopters and 12.0% of non-adopters had no formal education. Therefore, it can be concluded that most of the sampled respondents in the study area were educated. This is in line with the findings of [20] who reported there was no significant difference in the educational status of adopters and non-adopters of improved cassava production technology because most farmers were educated. The results showed that 62% and 54.7% of the adopters and non-adopters in the study area respectively had between one to five people per household. Mean household size for the study area was 5. This is corroborated by the work of [20] who found no significant difference in the household size of adopters and non-adopters. The result also revealed that majority of the respondents were married in the study area.

The study also showed that the mean farming experience of the farmers was 16.4 years and 18.4 years for adopters and non adopters respectively. The higher in the years of farming experience for non-adopters could be part of the reasons for not adopting improved cassava varieties in the study area. This study affirmed the findings of [5] on cassava production that a good proportion of the respondents have farming experience of about 20 years or less. It is expected that farmers in the study area should be knowledgeable in up-taking production risks. This suggests that the farmers had enough experience in cassava production to make the best decisions that will help boost their productive capacity. The average land area cultivated by the farmers was 1.99 and 1.28 hectares respectively. This implies that majority of the respondents in the study area are small scale farmers. This result

is in conformity with [4] that over 90 per cent of Nigerian farmers are small-scale farmers who cultivate less than 5
hectares. According to [16], the probable reason for the small-scale farm size was because of the low level of mechanization of traditional agriculture or owing to land tenure problems.

The findings also revealed that majority of the respondents had no access to credit. This might have affected the cassava farmers by hindering them from performing at optimal level. This is in line with the findings of [8] who posited that there are credit market imperfections in Nigeria and this could limit the investment and operation of the farms. The result also shows that 72% and 16% of adopters and non-adopters respectively had access to extension agents while 28% and 84% of adopters and non-adopters respectively had no access to extension agents in the study area. This implies that most of the farmers that adopted improved cassava varieties in the study area were privileged to benefit from extension education and training which would have impacted the farmers positively in terms of information and innovative technologies to take good decisions that will increase their production level. Most of the non-adopters however, were not able to access the extension agent which may be the reason for their dis-adoption in the study area. This result is in line with the findings of [20] who affirms access to extension agent as a strong determinant of adoption of improved cassava production. About 39.2% and 37.3% show the percentage of adopters and non-adopters that respectively owned their land personally. There will be minimal level of land fragmentation in the study area because both adopters and non-adopters have low percentages for land acquisition through inheritance. However, purchased land maybe used as collateral to access credit facility in production process.

Table 1. Respondents' Distribution by Socioeconomic Characteristics

Variable	Adopter		Non-Adopters	
	Mean	Dominant Indicator	Mean	Dominant indicator
Age	42.96	67.1% falls below or equals 44 years (active)	43.70	61.4% falls below or equals 44 years (active)
Sex		79%		65%
Education Level		93.7% had formal education		88.0% had formal education
Household Size (Number)	5.4	62% between 1and 5 persons	5.4	59% between 1 and 5 persons
Marital Status		73.4% married		80% married
Farming Experience (Years)	16.4	45.6% between 1and 10 years	18.4	42.8% between 1and 10 years
Farm Size (hectare)	1.99	67.1% had less than or equal to 2 ha	1.28	85.3% had less than or equal to 2 ha
Access to Credit		75.9% had no access		76.3% had no access
Access to Extension Agents		72% had access		16% had access
Method of Land Acquisition		39.2% through purchase		37.3% through purchase

Source: own processing.

Estimation of Adoption and Impact of Adoption on Downside Risk Exposure

The full information maximum likelihood approach is employed to jointly estimate the selection and outcome equation in the specification. Table 2 presents the estimates for downside risk exposure. The coefficients of the ESR estimates reported in the second column of Tables 2 is the selection equation estimates, while the fourth and sixth columns report the impact of adoption on adopters and non-adopters. As stated in the empirical specification, identification of the model requires that at least one variable in the selection equation should not appear in the outcome equations. In ESR specification, the variable awareness of the importance of improved cassava varieties is used as an identifying instrument. It is expected that farmers' level of awareness about ICV will influence adoption decisions but not directly on downside risk exposure [25].

This analysis relied on a moment-based specification of the stochastic production function for the estimation of downside risk exposure [6]. The approach captures the effects of ICV and other characteristics on the mean, variance, and skewness of cassava production. However, the variance does not distinguish between unexpected bad events and unexpected good ones. On that basis, it seems important to consider skewness in risk analysis. An increase in the skewness of yield means a reduction in downside risk exposure (e.g., a decrease in the probability of crop failure) [23].

The likelihood ratio test for joint independence of the equation in the ESR specification shows that the equation is dependent. The correlation coefficient ρ_1 and ρ_2 in the specification are both statistically significant, indicating that the selection bias due to unobservable factors occurred in adoption. Therefore, using ESR model, which accounts for both observable and unobservable factors, is appropriate in this study [15]. Since ρ_1 is negative and ρ_2 is positive, it implies that adopters with higher skewness have a lower probability of crop failure after adopting the improved cassava varieties than the non-adopters. However, non-adopters of ICV with lower skewness have a higher probability of crop failure than the adopters.

Given that the empirical result in the selection equation can be interpreted as normal probit coefficients, the result for variables in Table 2 represents the probability of adopting improved cassava varieties and effects of adoption.

Table 2. Full Information Maximum Likelihood Estimates of Endogenous Switching Regression Model for Adoption and Impact of Adoption on Downside Risk Exposure

	Selection		**Adopters**		**Non-adopter**	
	Coefficient	**t-value**	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Constant	-1.316	-4.42	0.298	0.23	0.951	2.11
Age	- 0.023	-0.31	0.003**	2.01	0.006**	2.22
Sex	- 0.269	-0.87	-0.185	-1.32	-0.255	-0.69
Farm Size	- 0.241*	-1.91	0.008	1.45	0.207*	1.79
Household Size	0.012	1.47	0.003**	1.98	0.042	0.78
Years of Formal Education	0.017*	1.93	0.003*	1.89	-0.047	-1.22
Farming Experience	0.014	0.21	-0.009	-1.64	0.009**	1.98
Membership of Association	0.077	0.45	0.116*	2.10	0.236	0.94
Extension Agent Visit	1.390***	6.56	-0.138	-0.98	-0.923	-1.65
Quantity of Herbicide	0.048***	4.07	0.006**	2.21	0.170***	6.92
Quantity of Cassava Stem	- 0.008	-1.42	0.003***	5.34	-0.005	-0.32
Quantity of Hired Labour	0.026**	2.00	0.002	1.44	0.020	1.32
Quantity of Fertilizer	0.007***	6.30	0.004*	1.90	0.005***	7.32
Awareness of import. of ICV	1.186***	5.67				
$\ln\sigma_1$			0.879***	4.01		
ρ_1			-0.184**	2.32		
$\ln\sigma_2$					0.209***	7.21
ρ_2					0.473***	3.14
Log likelihood	-190.16					
Likelihood ratio of independence: $\chi^2(1)$			31.78**			

Source: own processing.
* Significant at 10% level; ** Significant at 5% level; *** Significant at 1% level

The coefficient of the variable farm size is negative and different from zero in the specification, indicating that as the farm size increases, it also increases the probability of being non-adopter of improved cassava varieties.

This could be due to large farm size increasing the cost of purchasing improved varieties. The estimate of the variable education, which is positive and statistically significant suggesting that more years of education increase the probability of being an adopter of improved cassava varieties. The result of years of education is in line with other findings like [2], which reveals that years of education are a strong determinant of technology adoption.

The access to extension agents is positive and statistically significant, indicating that farmers with more contacts with extension agents are more likely to adopt improved cassava varieties. The result reveals that the increase in the extension contact increases the probability of being an adopter of improved technology. The result on extension contact is in line with other findings like [12], which showed that extension is a strong determinant of technology adoption.

Also interesting is the effects of the quantity of herbicide used variable, which differs significantly from zero and positive in the selection specification. It reveals that as the quantity of herbicide used increases, there is an increase the probability of adopting ICV.

The quantity of hired labour is positive and different from zero, suggesting that an increase in the quantity of hired labour increases the probability of adopting ICV by the farmers. The result may imply that farmers can hire additional labour in the cultivation of ICV after adoption. In the same vein, the positive and statistical significance of the quantity of fertilizer used is an indication that increasing the use of fertilizer will likely increase the probability of adopting ICV. Also, interesting is the estimate of the variable awareness of the importance of improved cassava varieties, which is positive and statistically significant in the specification. It reveals that as the level of awareness of the farmers increases there is an increase in the probability of adopting ICV. The increase in awareness may be because of information from the extension agents or education.

The estimates in the outcome equations in the columns for adopters and non-adopters in Tables 2 show the impact of farm and household characteristics on downside risk exposure for adopters and non-adopters. The impact estimates suggest that age influences the level of downside risk exposure among adopters of improved cassava varieties. The positive and statistically significant coefficient indicates that as the age of the farmer increases, it reduces the probability of crop failure which may be because of the experience they acquire in the production of cassava. The positive and statistically significant estimate of the household size for adopters indicate that higher household is more likely to reduce the probability of crop failure, which may imply that increasing household size will be available for farm operations in place of hired labourers who do not care about crop survival. The positive coefficient of years of formal education in the outcome equation for the downside risk exposure specification indicates that as the years of formal education increases, the probability of crop failure for adopters reduces. The result implies that as the years of formal education of farmers increase it also increases the probability of adopting improved cassava varieties which in turn reduces the probability of crop failure. The positive coefficients of membership of the association in the downside risk exposure-outcome specification indicate that membership of the association is significant as it reduces the downside risk exposure (probability of crop failure) for the adopters. The result implies that belonging to one form of association or the other makes bulk purchases of inputs easy reducing downside risk exposure.

The estimate for the quantity of herbicide used is positive and statistically significant for adopters and non-adopters' downside risk exposure specification indicating the positive impact of quantity herbicide on skewness (probability of crop failure). The farmers use more herbicide to reduce the effect of weed on the crop thus, reducing the possibility of crop failure for the adopters and non-adopters.

The estimate for the quantity of cassava stem variable is positive and statistically different from zero for adopters in the downside risk exposure. The result indicates that as the quantity of cassava stem used increases it lowers the probability of crop failure. For the adopters of improved cassava varieties, an increase in the quantity of stem planted translates to higher output, hence increase household welfare. The variable quantity of fertilizer used has positive and significant impacts on downside risk exposure for adopters and non-adopters of improved varieties in the specification. This finding suggests that as the quantity of fertilizer used increases for adopter and non-adopters of improved cassava varieties, the probability of crop failure is reduced. However, the increase in quantity of fertilizer used by non-adopters may not translate to an increase in welfare for them. The variable farm size has a positive and significant impact on downside risk exposure for non-adopter in the specification. This finding suggests that as the farm size increases, farmers may not acquire enough improved varieties that will cover the farm reducing the skewness of production in the study area. The estimate for the farming experience is positive and statistically different from zero for non-adopters in the downside risk exposure specifications for non-adopters. The result indicates that as farming experience increase, skewness also increases for non-adopters as farmers use experience gathered in production years for management of cassava, hence increase in household welfare.

Impact of ICV cultivation on the households' downside risk exposure

The impact of adoption on households' downside risk exposure was examined by the average treatment effects (ATT) on the expected outcomes estimated. Table 3 presents the ATT estimates of the Endogenous Switching Regression specification for downside risk exposure. These ATT estimates account for other confounding factors including selection bias arising from potential systematic differences between adopters and non-adopters. The results reveal that adoption reduces downside risk exposure. Specifically, the adoption of improved cassava varieties contributes to higher skewness (lower probability of crop failure) at 1.342 and that of non-adopters at lower skewness (higher probability of crop failure) at 0.543. The higher skewness implies a lower probability of crop failure from adopters of ICV. These findings follow other studies, which report that the adoption of new agricultural technologies can reduce the probability of crop failure. (e.g., [3]).

Table 3. Impact of Improved Cassava Varieties Cultivation on Farmers Downside Risk Exposure

Variable	**Adopters**	**Non-Adopters**	**ATT**
Downside risk exposure (Skewness)	1.342	0.543	0.799***

Source: own processing
* 10% level; ** 5% level; *** 1% level

CONCLUSIONS

This study assessed the impact of the adoption of improved cassava varieties on the downside risk exposure of farming households' in Ondo State, Nigeria. About 87.3% of the farmers adopted TME 419 which is the most widely adopted variety among the introduced improved cassava varieties in the state. The results also showed that the cultivation of improved cassava varieties in the study area reduced the downside risk exposure (probability of crop failure) of cassava farming households thus increasing their welfare. The results also demonstrated that, if the impact of ICV on these outcomes was estimated without accounting for observable and unobservable factors in the adoption decision process, sample selection bias could have occurred. Therefore the following recommendations were proffered based on the findings of this study:

- Government policy should be geared towards making education affordable and accessible at all levels. Adult and non-formal education will be of great assistance to the aged farming households.
- Extension agents should be supported by both government and non-governmental organizations to visit the farmers regularly and orientate farmers about input combinations that can, therefore, increase the farm output.

- There is a need to facilitate the development of infrastructures by the government among communities in the study area.

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