Socio-economic Determinants to Adoption of Tropical Mosaic Selection (TMS) Cassava Varieties by Small- holder Farmers in Abia State, Nigeria

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***Abstract*: The study was to determine factors influencing the rate and level of adoption of Tropical Mosaic Selection (TMS) cassava variety with presumptuous that the two decisions process were separate. The double-hurdle model was employed to address the objective with this important peculiarity in mind. Structured questionnaire was used to obtain information from one hundred and twenty cassava farmers that were selected using multi-staged random selection procedures. Results indicated that 56.7%of the sampled farmers reported adoption of TMS cassava variety with a mean proportion of 0.48. Farmers' decision on adoption of TMS cassava technology was positively affected by extension services, farm size, educational level and fertilizer . On the other hand, farmers' decision on level of adoption of improved cassava varieties was significantly affected by years of adoption experience and extension services that were positively signed, whilst fertilizer had indirect relationship with the dependent variable. The need to enhance the farmers' access to educational programme, extension services and adequate farm holding were recommended**

***Keywords*: Adoption, Double-hurdle, TMS cassava variety, Rate and Intensity, Nigeria.**

I. INTRODUCTION

Innovations in agriculture have been central among approaches for addressing food insecurity through increased productivity, outstandingly cassava (Ume, Onuh, Jiwuba, and Onunka, (2018). Cassava is a perennial shrub of the family *Euphorbiaceae* and staple food for more than 200 million people in most countries in sub-Sahara Africa (Ibitoye, 2011). Nigeria is the largest producer of cassava in the world (47,274,320 metric tons in the year 2017) with about 21 percent of world cassava production (FAOSTAT 2018). The development and introduction of improved cassava varieties has long been documented as one of the strategic approaches for transforming the cassava industry and for boosting the welfare of Nigeria's rural populace who are predominantly farmers (Nwakor, Ifenkwe, Okoye, Onummadu, Anyaegbunam, Ekedo, and Onyia; 2010).

However, among numerous improved cassava varieties developed by International Institute for Tropical Agriculture (IITA) and National Root Crop Research Institute(NRCRI) in collaboration with government of Federal Republic Nigeria was Tropical Manihot Selection (TMS). This variety TMS although exists under different cultivars (TMS 50395, 63397, 30555, 4(2)1425, TMS, 30211 and 30572) but has singular characteristics of being tolerant to Cassava mosaic disease (CMD) and Cassava Spider mite (CSM), low in cyanide content, drought resistant, early maturing, and high yielding (Ume, et al; 2018). Amongst the TMS varieties, TMS 30572 variety was the most popular, especially among Nigeria farmers who process it as gari for sale in urban markets (Nweke 2009).

Nevertheless, Agricultural Development Programme, (ADP), higher institutions, research organizations, the Ministry of Agriculture and Non-Governmental Organizations (NGOs) champion the course of distributing the technology to farmers in both and rural and urban areas. For example, ADPs in the thirsty six States of the country and Abuja (Federal capital territory) through Rural Infrastructural (RID), their multiplication unit had distributed more than a millions of the cassava cuttings to different parts of the country. The scheme involved distributing of five bundles of fifty cuttings to individual farmers with limited extension follow up, as par technical advice on adherence to cropping geometry (1mx1m spacing), use of inorganic fertilizer; pesticides application, adequate disease control, timely weeding and cultural practices (Nwakor, *et al*; 2010).

Although, cassava, particularly TMS variety is of premeditated prominence on economic development and food security in Nigeria, systematic studies have not been conducted to assess the decision to adopt and intensity of use of the variety. Studies on factors influencing farmers' decision to invest on cassava variety are non-existent. Information as relates to use of the improved cassava and associated improved production recommendations is very limited. The objective of this research is to examine the rate and extent of adoption of TMS cassava variety; and to identify and quantify factors that influence adoption of TMS cassava variety production in rural small-scale cassava production systems. This research marks distinctiveness amid factors influencing the decision to adopt and the decision on how much to adopt TMS cassava variety. Herein, adoption rates in this study connote the proportion of farmers who have adopted TMS cassava variety. The intensity of adoption is the definite proportion of TMS variety that a given household possess. The paper was organized as follows. The next section discussed theoretical model and empirical specification. Section 3 outlines the Materials and methods and results and discussion. Finally, conclusions and recommendations were put in the last section.

II. MATERIALS AND METHODS

Study Area

The study is carried out in Abia State of Nigeria. Abia State is located between latitudes $04^0$45'and $04^0$41' North of Equator and longitudes $7^0$57 and $08^0$54 East of Greenwich Meridian. It has population of 284.104 million people (NPC, 2006) and land area of 6,420 kilometre square (km^2) with. It has average annual rainfall of 1800-2000mm and temperature range of 22^0c-38^0c throughout the year. The inhabitants are farmers Most of the land is arable with the farmers producing cassava, yams, maize, potatoes, rice, cashews and plantains and The animals reared in the place are pigs, poultry, goat, sheep and rabbit. The off- farm employment engaged by the farmers are salon, tailoring, petty trading, auto mechanics and driving.

Sampling Technique and Sample Size

A multi-stage random sampling technique was used to select zones, blocks, cycles and respondents. First, two agricultural zones were purposively selected from four zones because of intensity of rice production in the areas. The selected zones were Abia North and Abia Central. Second, three blocks were randomly selected from each of the selected zones. This brought to a total of six blocks. Third, ten circles were randomly selected from each of the six blocks, making a total of sixty circles. Finally, two respondents were selected from each of the sixty circles. These brought to a total of one hundred and twenty (40 adopters and 80 non adopters)for detailed studies

Method of Data Collection

Structured questionnaire and oral interview were used to obtain primary data for the study.

Method of Data Analysis

Double hurdle model was used to capture the objective of the study

Model Specification

Theoretical model and empirical specifications

Farmers maximize their esteemed utility in line with von Neuman Morgenstern utility function delineated to wealth (W). Here, farmers encounter problems in relation to making decision on the choice between two alternate practices, the i^{th} farmer equates the foreseeable utility with the contemporary technology, denoted as $BN_{mi(}(X)$ to the expected utility with the traditional technology, connoted as $BN_{ti}(X)$. The dimensions of the insights and risk attitudes of farmers in relation to farming technology are not defined. However, Teklewold,*et al;* (2006) stated that extrapolations as par the factors can sway the distribution and expected utility of the technology under evaluation. These factors are employed as a vector 'X' of attributes of the choices made by farmer 'i' and ε_i is a random disturbance as result of unnoticed difference in preferences, features of the alternatives, and errors in optimization. With information on usual discrete choice analysis known coupled with regulation of the extent of non-linearity in the likelihood function, $BN_{mi(}(X)$ and $BN_{ti}(X)$ could be assigned as,

$BN_{mi(}(X) = \alpha_z M_i + \varepsilon_{zi}$ . . . . (1)
$BN_{ti}(X) = \alpha_t M_i + \varepsilon_{ti}$ . . ……………………………….. (2)

The variance in estimated utility as reported by Teklewold, et al; (2006) could be denoted as $BN_{mi(}(X) - BN_{ti}(X) = (\alpha_Z X_i+\varepsilon_{Zi}) - (\alpha_t M_i+\varepsilon_{ti}) = (\alpha_Z-\alpha_t)M_i + (\varepsilon_{Zi}-\varepsilon_{ti}) = \alpha M_i + \varepsilon_i$ . . . . (3). . .The farmers' preference for the contemporary technology could ensue if; $BN_{mi(}(X) - BN_{ti}(X) > 0$; while, that of the traditional technology will be $BN_{mi(}(X) - BN_{ti}(X) < 0$.The choice of TMS adoption as reported by Agwu, et al; (2006) could be assumed to be the end result of farmers'socio-economic characteristics and farmers' technological preference. However, the empirical analysis permits for inquiry into the decision on whether or not to adopt TMS and the restricted level of the technology if the initial adoption decision was made. Numerous postulates can be deduced from these two sets of decision - factors that affect both adoption and intensity of adoption the improved cassava . Education boosts farmers' prudency in management of resources and in being receptive to new innovations compare to farmers that are less educated (Nweke, 2009).

Also, farmers' farm holding, especially those with large farm sizes as reported by Ume, *et al*, (2018) reflects among others their (farmers') income level, which is capable of swaying their decision to technology adoption. Likewise, because of important of in organic fertilizer in boosting crop yield, farmers' access to the resource according to Agwu, (2007) could impact positively on the decision of adopting of improved cassava varieties. As well, agricultural extension services aids processors in taking decision as relates to technology adoption through dissemination of agricultural innovation and the associated technical assistants (FAOSTAT; 2018). .

Econometric specification of Double hurdle model

Most censored data model has comparable way of determining non-adoption and the intensity of adoption. The aforesaid postulation may not prevail, especially in situation where a significant number of farmers never response positively to technology adoption, no matter the circumstance (Teklewold; 2006). Here, Tobit model, one of the censor model is used to determine t farmers' decision to adopt and much to adopt can be made jointly or separately. This situation can result only in situation where the two decisions are influenced by the identical set of stimuli (Alene, et al, 2012). In the double-hurdle model, both hurdles have equations accompanying with them, integrating the effects of farmer's characteristics and conditions. Such explanatory variables may reflect in both equations or in either of one. It is imperative to state that a variable posturing in both equations may have opposite effects in the two equations(Labeaga, 1999). The double-hurdle model is a simplistic of the Tobit model, in which two discrete stochastic procedures have the attribute of making decision to adopt and level or extent of adoption of technology. The Di of equation of Double-hurdle model, as stated by Teklewold, (2006) was

$$\left.\begin{array}{l} Di = 1 \text{ if } Di^* > 0 \text{ and } 0 \text{ if } Di^* < 0 \\ Di = \alpha' Z_i + U_i \end{array}\right\} \quad .....(4)$$

Di = a latent variable that takes the value 1, if the farmer adopts the improved cassava variety, otherwise, 0. Z is the vector of household characteristics, α is the vector of the parameter. The level of adoption is given as

$$\left\{\begin{array}{l} Y_i = Y_i^* \quad \text{if} \quad Y_i^* > 0 \text{ and } D_i^* > 0 \\ Y_i = 0 \quad \text{otherwise} \\ Y_i^* = \beta' X_i + V_i \end{array}\right\} \quad ..(5)$$

here Y_i^* = the observed answer to the proportion of the improved cassava variety, X_i .is the vector of the individual characteristics, β' is the vector of the parameter

$$\left\{\begin{array}{l} U_i \sim N(0,1) \\ V_i \sim N(0,\sigma^2) \end{array}\right\} \quad ....(6)$$

The loglikelihood function for Double- Hurdle model

$$\text{Log } L = \sum_0 \ell n\left[1 - \Phi(\alpha Z_i')\left(\frac{\beta X_i'}{\sigma}\right)\right] + \sum_+ \ell n\left[\Phi(\alpha Z_i')\frac{1}{\sigma}\phi\left(\frac{Y_i - \beta X_i'}{\sigma}\right)\right]$$

………………………(7)

Underneath the postulation of independency between the error term --- and …the model as stated by Cragg, (1971) equal to a mixture of truncated regression model and univariate probit model.The Tobit model as already stated arises if $\lambda = \frac{\beta}{\sigma} \text{ and } X = Z.$ ………………………(7).

The Double hurdle model is tested against Tobit model. The Tobit log- likelihood is the summation of log- log likelihoodof the truncated and the probit model independently and employ a likelihood ratio (LR) test. The LR – statistic could be calculated using Green, (2000).

$$\Gamma = -2[\ell n L_T - (\ell n L_P + \ell n L_{TR})] \sim \chi_k^2 \quad ……..(8)$$

Where Lt = likelihood for the probit model; L_{TR} = likelihood for the truncated regression model, and K is the number of independent factor or variable as contained in the equations, Where the equation under testing is specified as;

$$H_0 : \lambda = \frac{\beta}{\sigma} \text{ and } \lambda \neq \frac{\beta}{\sigma}. \quad …………………..(9)$$

Ho will be rejected in line with already stated significance level, if $\Gamma > \chi_k^2.$

Table 1 ; Definition of Variable

Variable	Definition	A priori sign
D (binary variable)	1 = if proportion of improved cassava varieties>0 and 0 otherwise	
Y	Proportion of TMS cassava varieties	
Age	Age of household in years	-
Educational Level	No. years of schooling	+
Access to inorganic fertilizer	Access; 1 and otherwise 0	+
No of Years of adoption Experience	No of years of adoption experience in years	+
Farm Size	Size of farm in hectare	+

III. RESULTS AND DISCUSSION

The dependent variable in the first stage probit equation was farmer's adoption of TMS cassava variety. This variable takes a value of 1, if the farmer adopts TMS cassava technology and 0 otherwise. A total of 40 households (33.3%) as shown in Table 2 reported adoption of TMS cassava technology during the period of the research. The quantity of improved cassava variety in the household was used as another dependent variable in the second stage truncated regression. The mean proportion of TMS cassava variety was 0.48 for the full sample and 0.56 for the adopting households. The explanatory variables comprised both the continuous and binary variables. The summary statistics for all the variables for the full, non-adopter and adopter of TMS cassava variety were contained in the Table 2.

Table 2 shows the results of the double-hurdle model. It shows the results of variables to elucidate distinctly the decision to adopt (D) TMS cassava production and to what extent (Y). To assess the Tobit model, a discrete log-likelihood function is maximized with the univariate normal probability, being detached from equation (7). The Tobit model's results are reported in the appendix. To evade the problematic or challenges of heteroscedasticity, Huber/White/Sandwich estimator of variances is employed in preference to the conventional maximum likelihood estimator of variances(Labeaga, 1998)

Table 2; Test Statistics of Double Hurdle

Variable	Probit	**Truncated Regression, Y(Y>0)**	Tobit
Wald χ^2 (LR χ^2)	60.8	54	104
Prob > χ^2	0.00***	0.00**	0.000***
Log- L	-107	0.63	-131
AIC(-LOG-L+k/N)	0.63	0.08	0.75
Number of observation, N	120	80	120

X^2-Test Double Hurdle versus Tobit: Γ= 112.37 > χ2 (12)=74.92

Note: ***, **and * refers significant at 1%, 5% and 10% probability level, respectively

Test statistics: Γ= 112.37 > χ2 (12)=74.92

From this table computation of test of statistics was as follows; Γ = -2[-131 – (-107+ (0.63)= 112.37. In the analysis, the first step is the testing of the Tobit model against the alternative of a probit plus a truncated regression model as contained in Table 2. The results of the formal test between the Tobit and the two-step modelling (using a probit plus a truncated regression) signify the confirmation of the dominance of the double hurdle model. Considering the values of log-likelihood v of the two Models estimated, the LR test results recommended the rejection of the Tobit model. This a situation where the value of the test statistic Γ= 112.37 greater than the critical value of the χ^2 distribution. For effectiveness of model selection criterion in order to ensure good measure, Akakie's Information Criterion (AIC) is incorporated. As result in the selection, the model with the lowest AIC is chosen. This endorses the glaring preeminence of the double-hurdle specification. This implies that the notion or the decision to apportion positive value for the quantity of TMS cassava variety and the decision as relates to how much to state is a function of diverse procedure.

The regression results (Annex 3) indicates that there were different set of variables behind the decision to adopt and the decision about how much of proportion of TMS cassava variety with the farmers.It can be observed that different sets of variables govern each process. In general, as shown in Table 3 the possibility of adoption of TMS cassava vareity was worthy, as an average farmer had about 56.7% predicted probability of adopting the technology. In terms of mean, an average household had about mean of 0.48 proportion of TMS cassava variety.

Table 3 Estimated Marginal Effects of Adoption of Cassava Technology

Variables	Probit D		**Truncated Regression, Y(Y>0)**	
	Coefficient	**RobustStd Err.**	***Coefficient***	*Robust Std. Err*
Gender	0.250	0.030	0.001	0.220
Educational Level	0.024	0.021**	0.001	0.221***
Farm Size	0.003	0.114	0.006	0.030*
Adoption Experience	O.034	0.017**	0.009	O.127***
Access to Inorganic Fertilizer	-0.245	0.083**	- 0.124	0.177***
Access to extension services	0.029	0.031**	0.005	0.040*

refers statistically significant at 10%, 5% & 1% respectively; Figures in parenthesis are standard error
Source; Field Survey; 2018

*,**and***

As shown in Table 4, the effects of explanatory variables, as hypothesized, farmers' decision on adoption of cassava production was significantly affected by extension services (+), farm size (+), fertilizer (-) and educational level(+) . On the other hand, farmers' decision on level of adoption of improved cassava varieties was significantly affected by years of adoption experience (+), fertilizer (-), extension services (+). Estimated changes in the probability of adopting TMS cassava variety and change in intensity of adoption with respect to changes in an explanatory variable are presented in Table 3. The double-hurdle model result reveals that farmers who had access to large farm holding are about 41 percent more forthcoming to adopt TMS cassava technology but not significant in the second hurdle . Literatures show that farmers total land holding serves as a good proxy for wealth status and income level through among others as collateral to finance at least part of their investments or for financing a new technology. More so, as excepted the coefficient of extension contact had the desired sign and statistically significant in both in the first and second hurdles i.e in the case of adoption decision and intensity of adoption decision. The marginal effect analysis result in Table 3 shows that the number of meaningful farmers’ access to extension service increases the chances of adopting the cassava technology by 31% with high chances of increasing the proportion of TMS variety in use by 40% Extension services aids farmers in taking decision as relates to technology adoption through dissemination of agricultural innovations and rendering the associated technical assistants (FAOSTAT; 2018)

In addition, the educational status of the farming household head was significant and positively signed to he/she adoption decision and extent of adoption of improved cassava in the two hurdles. Those farmers with many number of years of schooling have higher probability to adopt the cassava technology by about 24% and conditional on adoption, farmers with high educational attainment have more odds of enhancing the quantity of improved cassava in use by 22.1%. Education boosts farmers' prudency in management of resources and in being receptiveness to new innovations compare to farmers that are less educated (Nweke, 2009).As well, fertilizer access by the farmers was an important factor in both hurdles. This variable had indirect effect on the likelihood of adoption decision and extent of adoption of TMS cassava technology. The farmers who had limited access to inorganic fertilizer, precisely have greater chances of having condensed prospect to adoption of the cassava technology by about 24.5%, and conditional on adoption, farmers with access to fertilizer is being linked to curtailing the proportion of improved cassava by 12.4%. However, because of important of inorganic fertilizer in boosting crop yield, farmers' access to the resource according to Agwu, (2007) could impact positively on the decision to adopt the improved cassava varieties. Also, the variable years of adoption experience of the farming household had positive signs in the first double hurdle and not in second. It is obvious that such farmers with high number of years of adoption experiences have high probability to adopt the improved cassava variety since they have more likelihood of abating the intricacies associated with technology adoption in order to maximize the output and profit at minimum cost (Ume, et al; 2018). Having the prevailing know-hows of benefits acquired from cassava production, farmers with high number of years of adoption experience in TMS cassava variety apt to have a 34% probability to adopt improved cassava.

IV. CONCLUSION AND RECOMMENDATIONS

This study assessed the determinants to adoption of tropical mosaic Selection (TMS) cassava variety by farmers in Abia State of Nigeria. Results indicated that 56.7%of the study farmers reported adoption of TMS cassava variety with a mean proportion of0.48. Farmers' decision on adoption of TMS cassava technology was positively affected by extension services, farm size, educational level, with fertilizer . On the other hand, farmers' decision on level of adoption of improved cassava varieties was significantly affected by years of adoption experience and extension services being positively signed, whilst fertilizer had indirect relationship. There is need for government to enhance the adoption and extent of TMS cassava technology by the farmers through exposing the farmers to educational programmes such as adult education, seminar, workshops and seminars. AS well, the extension agents should not only be motivated to be animated to their duties but there is need to narrow the gap between extension agents-farmers ratio through employing more graduates into the vacation. In addition, the Nigeria1977 "land use decree" should be revisited, so that genuine farmers will have access to land in order to improve their rate of technology adoption need to enhance the farmers' access to education, extension services and adequate farm holding ere recommended.

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ANNEXES

.Table 1 Sample Summary Statistics

	Non-adopting (N=80)		Adopting(N40)		Full Sample(N120)	
Variable	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Y	-	-	0.56	0.32	0.24	0.34
Gender	0.82	-	0.84	-	0.92	-
Educational Level	1.94	-	1.69	-	1.98	-
Farm Size	6.37	3.47	7.36	3.22	7.12	3.64
Experience	-	-	2.54	2.71	1.03	2.23
Inorganic Fertilizer	0.54	-	0.76	-	0.72	-
Extension Service	0.16	-	0.48	-	0.29	-

Source; Field Survey, 2018

Table 2 Adopt and Intensity of Adoption of TMS Cassava Variety

Variable	Study Area(Abia)
Rate of Adoption	
Percent of farmers	56.7(68)
Intensity (Proportion) of adoption	
Mean	0.48
Standard deviation	0.38
Number of adopters	54

Source; Field Survey, 2019

Table 3. Maximum likelihood estimation of double-hurdle Vs. Tobi model

	Probit D		**Truncated Regression, Y(Y>0)**		**Tobit**	
Variable	Coefficient.	Robust Std. Err	Coefficient.	Robust Std. Err	Coefficient.	Robust Std. Err
Gender	0.0654	0.065**	0.0032	0.0543*	0.2567	0.0098
Education	0.0663	0.2214**	0.4457	0.0066	0.0077	0.1137***
Farm Size	0.9900	0.9090	0.5500	0.0043*	0.9087	0.0054**
Experience	0.0543	0.0855**	0.2341	0.0032	0.5903	0.0091*
Fertilizer	-0.8800	0.4422**	- 0.3322	0.2266*	- 0.5511	0.1188***

Wald χ^2 (LR χ^2)	60.8	54	104
Prob > χ^2	0.00***	0.00**	0.000***
LOG-L	-107	0.63	-131
AIC(-LOG-L+k/N)	0.63	0.08	0.75
Number of observation, N	120	80	120

Source; Field Survey; 2018