Effect of Agricultural Insurance Adoption on the Food Security of Smallholder Rice Farmers in North Central Nigeria: Application of Endogenous Switching Regression

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Abstract

The impact of agricultural insurance adoption on the food security of smallholder rice farmers remains inadequately understood. Thus, this study investigated the effect of agricultural insurance adoption on the food security of smallholder rice farmers in North Central Nigeria. The study utilized data from 400 smallholder rice farmers consisting of 200 adopters and 200 non-adopters of agricultural insurance selected from 16 communities of four States in North Central Nigeria using multistage sampling technique. The collected data were analysed using independent sample t-test and endogenous switching regression model (ESRM). The findings showed that the mean food security of adopters of agricultural insurance in the study area was 1.9728 while that of the non-adopters was 1.0272. The t-test result shows that there was significant difference at 1% in the food security of adopters and non-adopters of agricultural insurance (t = 6.963, p < 0.01). The ESRM showed that rice farmers who adopted agricultural insurance were not better than random rice farmers in terms of food security and vice-versa. The ESRM also revealed that agricultural insurance adoption and food security of smallholder rice farmers were significantly influenced by their socio-economic characteristics. The study recommended that campaigns on farmers' awareness of agricultural insurance should be intensified by stakeholders in the rice industry to encourage patronage; and that policies and programmes targeted at making smallholder farmers subscribe to agricultural insurance as well as to increase their level of food security should take into consideration the socio-economic characteristics of the farmers in their design and implementation.

Key words: Agricultural Insurance; Adoption; Food Security; Rice Farmers; North-Central Nigeria

Introduction

Smallholder rice farmers in North Central Nigeria face numerous challenges that undermine their food security, including climate variability, market uncertainties, and limited access to financial resources (Adah *et al*., 2016, Gbigbi and Ndubuokwu, 2022). According to (Adah *et al*., 2016, Asamoah, 2019, Dhakal, 2019, Adeoti *et al*., 2020, Okpukpara *et al*., 2021), these challenges pose formidable risks to crop yields and income stability, threatening the livelihoods of smallholder rice

While agricultural insurance has been proposed as a potential mechanism to mitigate these risks (Adeoti *et al*., 2020, Okpukpara *et al*., 2021, Gbigbi and Ndubuokwu, 2022), its adoption among smallholder farmers remains low. In a study on the determinants of crop farmers' participation in agricultural insurance in Nigeria, Abdulmalik *et al*. (2013) revealed that there is a low level of participation in insurance activities in Nigeria.

The lack of empirical evidence on the relationship between agricultural insurance adoption and food security among smallholder rice farmers in the region hampers informed decision-making and policy formulation. Thus, this study addresses the following key issues: What factors influence the decision of smallholder rice farmers in North Central Nigeria to adopt agricultural insurance? Are adopters better positioned in terms of food security compared to non-adopters? What are the factors that influence food security of smallholder rice farmers in North Central Nigeria?

The answers to these questions are vital for understanding the effectiveness of agricultural insurance as a risk management tool and its potential contribution to improving the food security of smallholder rice farmers in North Central Nigeria. By conducting a comparative analysis between adopters and non-adopters of agricultural insurance and identifying the determinants influencing both adoption and food security, this research provides evidence-based insights that can inform policy interventions and support the development of sustainable agricultural practices in the region.

The findings of this study are expected to offer valuable insights for policymakers, agricultural stakeholders, and development practitioners aiming to enhance food security and promote sustainable agricultural development in Nigeria and similar contexts. Moreover, the methodological approach utilized in this research contributes to the methodological advancements in evaluating the impact of agricultural interventions on smallholder farmers' welfare. Overall, this study contributes to the ongoing discourse on the role of agricultural insurance in improving the livelihoods and resilience of smallholder farmers, thereby advancing efforts towards achieving food security and poverty alleviation goals

Methodology

The Study Area

The study was conducted in North-Central Nigeria. The North Central region of Nigeria comprises of six States, namely, Plateau, Niger, Nasarawa, Kwara, Kogi and Benue States. Farmers who

engaged in arable crop production like rice, yam, cassava, sweet potato, maize, vegetables, soybeans as well as livestock like poultry, goat, sheep, piggery, cattle and fish abound in the region.

The region covers latitude $7^0 00^/$-$11^0 30^/$ North of the equator and longitude $4^0 00^/$-$11^0 00^/$ East of the Greenwich meridian (Olanrewaju and Fayemi, 2015). North-Central Nigeria enjoys the tropical continental climate characterized by wet and dry seasons. The wet season is synonymous to planting season since agriculture in the area is rain-fed. Mean annual rainfall ranges between 1200mm and 1500mm while temperature is high almost throughout the year except during harmattan period which begins in November and last until February. The weather is cold and dry during the period coupled with hazy atmosphere and dust particle flowing around. The vegetation of the North-Central Nigeria cut across the three savannah belts (Guinea, Sudan, and Sahel) and this is one of the reasons why both roots and cereals cropping are very popular in these ecological zones.

Population of the Study

The study population comprised all adopters and non-adopters of agricultural insurance packages in the North-Central Nigeria who are rice producers in the 2022/2023 cropping season.

Sampling Technique and Data Collection

The study adopted multi-stage sampling technique to select a sample of 400 rice farmers consisting of 200 adopters and 200 non-adopters of agricultural insurance from 16 randomly selected communities of four randomly selected States in North Central Nigeria. Structured questionnaire was used for the data collection.

Analytical Techniques

The study employed independent sample t-test, and endogenous switching regression model to analyze the collected data. Independent sample t-test was used to compare the food security of adopters and non-adopters of agricultural insurance among smallholder rice farmers while endogenous switching regression model was used to identify the factors that influence agricultural insurance adoption and food of smallholder rice farmers.

The endogenous switching regression model was specified as follows:

Selection equation:

$P_i= a_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + \varepsilon_i$ ………………… (1)

P_i = probability that a rice farmer adopted agricultural insurance (1= adopted, 0 = did not adopt)

a_0 = Constant

b_1-b_8 = coefficients of predictors

X_1 = Age (years)

X_2 = Farm size (ha)

X_3 = Farming Experience (years)

X_4 = Cooperative Membership (member=1, Non-member=0)

X_5 = Farm output (kg)

X_6 = Annual income (Naira)

X_7= Level of education (years)

X_8 = Sex (male=1, female=0)

ε_i= Error term

The *a priori* expectation was that the coefficient of sex, level of education, farming experience, membership of cooperative, farm size, farm output, and annual income would be positive while that of age would be negative.

Food security equation for adopters and non-adopters of agricultural insurance:

$$Y_i = a_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where:

Y_i = food security (food security index)

a_0 = Constant

b_1-b_7 = coefficients of predictors

X_1 = Age (years)

X_2 = Farm size (ha)

X_3 = Farming Experience (years)

X_4 = Cooperative Membership (member=1, Non-member=0)

X_5 = Farm output (kg)

X_6 = Annual income (Naira)

X_7= Level of education (years)

ε_i= Error term

The *a priori* expectation was that the coefficient of level of education, farming experience, membership of cooperative, farm size, farm output, and annual income would be positive while that of age would be negative.

Results and Discussion

Food Security of Adopters and Non-Adopters

Analysis of Table 1 shows that the mean food security index of adopters of agricultural insurance in the study area was 1.9728 while that of the non-adopters was 1.0272. This indicates that food security improved more for adopters of agricultural insurance (1.9728) than for non-adopters (1.0272).

Table 1: Comparison of the food security of adopters and non-adopters of agricultural insurance packages

Smallholder farmers	Mean food security	Mean food security difference	t-test	p-value
Adopters	1.9728	0.94568	6.963	0.000***
Non-adopters	1.0272			

Source: Field survey data, 2023   *** = significant at 1%

The difference between their mean food security indexes was positive (0.94568) indicating increase. The t-test analysis reveals there was significant difference in the food security of adopters and non-adopters of agricultural insurance (t = 6.963, p >0.05). The significant difference in the food security of adopters and non-adopters of agricultural insurance could be attributed to the high productivity by the adopters when compared to that by the non-adopters in their rice production business. The implication is that agricultural insurance has enhanced the capacity of the adopters to realize increase in their food security which could be attributed to increase in their farm output. This is in consonance with Ranganathan *et al*. (2019) who reported a 47% increase in rice yields among rice farmers who adopted crop insurance in Eastern India.

Determinants of Agricultural Insurance Adoption and Food Security of Smallholder Rice Farmers

The socio-economic factors influencing agricultural insurance adoption and food security among smallholder rice farmers in the study area are presented in Table2.

Table 2: Socio-economic determinants of agricultural insurance adoption and food security of smallholder rice farmers

Variables	Selection Model Adopters/Non-Adopters	Food security equation	
		Adopters	Non-adopters
Constant	-37.25***	0.87^{NS}	-4.29**
	(3.94)	(3.51)	(1.70)
Age	-0.13^{NS}	-0.84***	-0.63**

	(0.45)	(0.27)	(0.27)
Farm size	-0.34^{NS}	0.079^{NS}	0.17^{NS}
	(0.30)	(0.15)	(0.18)
Farming experience	0.26^{NS}	-0.063^{NS}	0.13^{NS}
	(0.20)	(0.10)	(0.13)
Membership of cooperative	0.32^{NS}	0.26^{*}	-0.33^{**}
	(0.24)	(0.15)	(0.13)
Farm output	-3.39^{***}	0.094^{NS}	-0.37^{NS}
	(0.46)	(0.30)	(0.23)
Annual Income	3.43^{***}	0.0027^{NS}	0.38^{**}
	(0.36)	(0.28)	(0.16)
Level of education	0.15^{NS}	0.83^{***}	0.71^{***}
	(0.32)	(0.23)	(0.17)
Sex	-0.043^{NS}		
	(0.17)		
/ln₁		-0.54^{***}	
		(0.051)	
/ln₂			-0.51^{***}
			(0.09)
/r¹		-0.056^{NS}	
		(0.38)	
/r²			-1.94^{***}
			(0.41)
Sigma_1		0.58^{***}	
		(0.029)	
Sigma_2			0.60^{***}
			(0.054)
rho_1		-0.056^{NS}	
		(0.38)	
rho_2			-0.96^{***}
			(0.033)
LR test of independent equations	23.16^{***}		
Wald chi square	45.87^{***}		

Source: Field survey data, 2023   Standard errors are in parentheses   *** = significant at 1%; ** = significant at 5%; * = significant at 10%; NS = not significant

Table 2 shows that the likelihood ratio test for joint independence of the three equations was statistically significant at 1%. The implication is that these three models are not jointly independent and should not be estimated separately. In order words, the three equations are dependent.

The covariance terms (rho_1 and rho_2) are non-zero indicating that the model shows endogenous switching (Maddala, 1986). This therefore justifies the use of the Endogenous Switching Regression (ESR) model.

The correlation coefficient rho_1 which shows the correlation between the agricultural insurance adoption equation and the adopters' food security equation was negative and not statistically different from zero. This implies that rice farmers who adopted agricultural insurance were not better or worse than a random rice farmer in terms of food security.
The correlation coefficient rho_2 which shows the correlation between the agricultural insurance adoption equation and the non-adopters' food security equation was positive and statistically different from zero. This implies that rice farmers who did not adopt agricultural insurance were not better than a random rice farmer in terms of food security.

The result of the estimates in Table 2 is in three parts. One part consists of the Probit model for the determinants of agricultural insurance adoption. The estimates of the coefficient for the Probit model are shown in the first column of Table 2.

The coefficient of farm output was significant at 1% and negatively related to agricultural insurance adoption. The negative sign of the coefficient which is at variance with the *a priori* expectation indicates that rice farmers with higher farm output were less likely to have accessed agricultural insurance. Increase farm output translates to more farm income which favours the uptake of insurance among farmers. According to Ntukamazina *et al.* (2017), on-farm income is positively correlated with the amount farmers are willing to pay as insurance premium. However, farmers with increased farm output and are less likely to adopt insurance are these who are aged with large household size. According to Gbigbi and Ndubuokwu (2022), the likelihood of farmers' willingness to patronize insurance decreases as the farmers become elderly and attributed this to the fact that older farmers are risk-averse and more conservative than the younger ones who are more innovative and receptive to new ideas. In addition, Njue *et al.* (2018) revealed that large households are often faced with complex expenditure priorities, hence low disposable incomes hinders households with high number of dependents to adopt agricultural insurance as a risk management instrument.

Annual income had a positive coefficient and statistically significant at 1%. The positive coefficient is in agreement with the *a priori* expectation implying that rice farmers with higher annual farm income were more likely to have accessed agricultural insurance. Annual farm income positively influence the amount farmers are willing to pay as insurance premium. This is in consonance with Ntukamazina *et al.* (2017) who reported that insurance premiums are paid with income and hence farmers with high farm income tend to have higher payment capacity than those with low farm income.

The coefficient estimates of the second stage switching regression model for food security are shown in the second and third column of Table 2. The results of the determinants of food security among rice farmers who adopted agricultural insurance is reported in the adopters' column and the

determinants of food security among rice farmers that did not adopt agricultural insurance is presented in the non-adopters column.

In the adopters' and non-adopters' column, the coefficient of age was significant at 1% and 5% respectively and negatively related to food security. Older farmers are less likely to be food secured as they do not have the required labour force to produce more food crops than their counterparts who are younger. This finding corroborates Funmilola and Patricia (2014) who revealed that as the household head advances in age, the probability of being food secured decreases.

Membership of cooperative in the adopters' column was significant at 10% and positively related to food security while in the non-adopters column, the coefficient of membership of cooperative was significant at 5% and negatively related to food security. Household heads that are members of farmer organizations have better access to extension services than non-member farmers because of a chance of frequent contact with extension agents. This contact exposes them to improved farming practices which translates to increase food production and hence their food security status. This finding corroborates Otunaiya and Ibidunni (2014) who reported a positive relationship between membership of cooperative society and food security status of farming households.

The coefficient of education in the adopters' and non-adopters' columns was significant at 1% and positively related to food security. Educated household heads usually practice family planning programs thereby limiting their family size when compared with their counterparts and thus become able to manage food demands of their households. Also, they engage themselves and their family members in various non-farm income generating activities thereby improving their food security status. This finding agrees with Agidew and Singh (2018) who reported a significant association between education and food security status.

In the non-adopters' column, the coefficient of annual income was significant at 5% and positively related to food security. Households with higher annual farm income are less likely to be food insecure owing to their financial capacity to take of their food requirement. This finding agrees with Assefa (2018) who reported that an increase in household total income decreases the probability of food insecurity by 6.3 percentage points.

Conclusion and Policy Implications

Evidence from the study shows that agricultural insurance adoption improved the food security of the smallholder rice farmers in the study area by 92%. The adoption of agricultural insurance by rice farmers in the study area as well as their food security were significantly influenced by their socio-economic characteristics. The farm output of these farmers decreases the likelihood of their adoption of agricultural insurance package while their annual farm income increases the likelihood of their adoption of agricultural insurance package. In the case of rice farmers who adopted agricultural insurance packages, age decreases their food security by 0.84%, while their membership of cooperative and level of education increase it by 0.26% and 0.83% respectively. In the case of rice farmers who did not adopt agricultural insurance packages, their age and

membership of cooperative decrease their food security by 0.63% and 0.33% respectively, while their annual farm income and level of education increase their food security by 0.38% and 0.71% respectively.

Based on the findings of the study, the following were recommended:

- Farmers' awareness of agricultural insurance should be intensified by the government and other stakeholders in the rice industry to encourage patronage through enlightenment campaigns utilizing faith based organizations, State extension services, farmers' cooperative society, and information communication technologies; and
- Policies and programmes targeted at making more smallholder farmers subscribe to agricultural insurance as well as to increase their food security should take into cognizance the socio-economic characteristics of the farmers in their design and implementation.

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