

Awareness–adoption gap for improved cassava varieties among smallholder farmers in Ogun State, Nigeria

Kazeem Aboaba

aboabakazeem@gmail.com

Michael Okpara University of Agriculture

Nsa Ayi

University of Cross River State

Florence Nse-Nelson

Michael Okpara University of Agriculture

Taofeeq Amusa

Michael Okpara University of Agriculture

Ndidiamaka Ekweanya

Michael Okpara University of Agriculture

Research Article

Keywords:

Posted Date: August 3rd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10385118/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Awareness–adoption gap for improved cassava varieties among smallholder farmers in Ogun State, Nigeria

Kazeem Aboaba^{1*}, Nsa Ayi², Florence Nse-Nelson¹, Taofeeq Amusa¹ & Ndidiamaka Ekweanya³

¹Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike Nigeria.

²Department of Agricultural Economics and Extension, University of Cross River State, Calabar, Nigeria.

³Department of Agricultural Extension and Rural Development, Michael Okpara University of Agriculture, Umudike, Nigeria.

***Correspondence:** aboabakazeem@gmail.com

Abstract

Despite strong policy emphasis on improved cassava varieties, productivity gains across Africa remain below potential due to a persistent gap between farmers' awareness and actual adoption. Most previous studies rely on probit or logit models which lead to potentially biased policy recommendations. This study overcomes this limitation by applying an Endogenous Switching Poisson Regression (ESPR) to obtain more reliable causal estimates of the determinants of awareness and adoption of improved cassava varieties. Primary data were collected from 288 cassava farmers using a multistage sampling technique and a structured questionnaire. Descriptive statistics and ESPR were used for analysis, results showed that 41% and 44% of farmers had access to extension service and were aware of improved cassava varieties, yet only 18% had adopted TME 419. The ESPR results indicate that awareness was significantly influenced by age ($p<0.01$), marital status ($p<0.01$), farming experience ($p<0.10$), household size ($p<0.10$), and access to improved inputs ($p<0.01$). Adoption was significantly driven by extension contact ($p<0.001$), age ($p<0.01$), education ($p<0.01$), secondary income ($p<0.01$), access to inputs ($p<0.05$), cultivated area ($p<0.10$), and awareness status ($p<0.01$). The study concludes that awareness alone is insufficient for adoption. Bundled interventions are recommended to enhance adoption outcomes.

Introduction

Today, cassava remains one of the most significant staple and industrial crops in sub-Saharan Africa, providing important food security, income and livelihood support for rural households. Several improved cassava varieties, developed through breeding programmes for yield, disease resistance, adaptability to climate change and processing qualities, have been produced over the years [24]. Despite the availability of these technologies, evidence across Africa suggests that the productivity gains associated with improved cassava varieties have not been fully realized because of persistent gaps between farmers' awareness and actual adoption. Empirical studies consistently show that while many farmers are aware of improved varieties, utilization rates remain considerably lower [20, 13, 31, 19, 1]. This indicates that awareness alone may not necessarily translate into adoption decisions, particularly where institutional, socioeconomic, and market-related constraints exist.

Significant welfare gains from the use of improved cassava varieties and technologies have been well documented. For instance, in Ghana, the adoption of improved cassava varieties significantly increased farm yields among adopters and non-adopters under counterfactual

conditions [3]. The same result was found in Nigeria, where adoption mitigated the probability of farming households facing negative production shocks and poverty incidence [37, 4]. Beyond cassava, studies on improved sorghum varieties and quality seed technologies have also revealed positive effects on household income, productivity, and welfare outcomes [16, 39]. These findings reinforce the importance of improved agricultural technologies in enhancing rural livelihoods. However, the relatively low adoption rates, however, suggest that there is a lack of knowledge about the pathways from awareness to adoption, even though benefits have been documented. The available evidence also demonstrates that a combination of socioeconomic, institutional, and market considerations affect awareness and adoption. Educational attainment has consistently been found to be a key influencer of awareness and adoption, and more-educated farmers tend to be better equipped to process information and consider new technologies [20, 31, 37]. Extension contact is also a key player in disseminating information and enabling technology uptake [7, 16, 4]. Likewise, cooperative membership, access to credit, farm size, market proximity, and access to planting materials have been found to affect farmers' choices of improved varieties [30, 25, 19]. Other information dissemination mechanisms, including demonstration plots, farmer-to-farmer interactions, media and extension visits have also been identified as important mechanisms shaping technology diffusion [19, 35, 32]. However, there are significant differences in the effectiveness of these mechanisms in different contexts, indicating that awareness formation is a complex process shaped by household characteristics and institutional conditions.

While awareness is often recognized as an important precursor to adoption, many studies do not explicitly model the specification of awareness as a behavioral decision. In the majority of empirical studies, awareness is either considered a dependent variable in adoption models or treated as a pre-existing factor prior to making adoption decisions [3, 4, 16]. However, evidence from several studies suggests that high awareness does not necessarily lead to the corresponding adoption levels. For example, in Benue, Rivers, and Ghana, high awareness levels were reported with moderate/low adoption of improved cassava varieties [31, 13, 19]. This disconnect implies that awareness and adoption may be influenced by different factors, and should not be treated as a single homogeneous decision process. Failure to distinguish between these stages may therefore conceal important behavioral and institutional dynamics affecting technology uptake.

In terms of methodological approaches, the literature on better technology adoption is still largely based on conventional binary response models (e.g., probit and logit regressions) [20, 30, 31]. These strategies can be useful into looking for correlates in adoption, but may assume that adoption decisions are exogenous and uninfluenced by unobserved selection processes. Consequently, such models may generate biased and inconsistent estimates, in which farmers select awareness or adoption categories based on observed and unobserved characteristics. Recent studies have attempted to address this limitation by applying Endogenous Switching Poisson Regression (ESPR) models to estimate treatment effects and counterfactual outcomes [3, 37, 38]. The studies found that there was indeed a selection bias and that Endogenous Switching Regression (ESR) was valuable in eliminating unobserved heterogeneity. However, within the literature on endogenous switching regression (ESR), awareness is rarely treated as the primary endogenous outcome. Instead, ESR has largely been applied to estimate the welfare impacts of adoption rather than the determinants of awareness itself [16, 39, 14].

Although there is an increasing empirical interest in better cassava technologies, there are significant gaps in knowledge that need to be addressed. First, limited attention has been paid to awareness as a distinct stage within the technology adoption pathway. Second, many of the existing studies are based on descriptive analysis or rely on a binary adoption model that fails to

capture the selection bias and unobserved heterogeneity [18]. Third, there is a lack of evidence from Ogun State, even though it plays a significant role in cassava production in southwestern Nigeria [11, 27]. Addressing these gaps is essential because farmers cannot adopt technologies they are unaware of, and the determinants of awareness may differ substantially from the determinants of adoption. Therefore, this study contributes to the literature by modelling the awareness of improved cassava varieties as an endogenous decision process using an Endogenous Switching Poisson Regression framework. This study reduces the effects of potential selection bias and unobserved heterogeneity, thereby providing a stronger picture of how socioeconomic and institutional characteristics affect farmers' awareness and adoption decisions in Ogun State.

Literature review

Theoretical review

This study is anchored on the Diffusion of Innovations (DOI) Theory proposed by Rogers [34], which explains how new technologies are communicated and adopted within a social system over time. The theory conceptualizes adoption as a sequential process comprising knowledge (awareness), persuasion, decision, implementation, and confirmation. According to Rogers [34], awareness is the first stage of the innovation-decision process and constitutes a necessary prerequisite for technology adoption because individuals cannot evaluate or adopt innovations of which they have no prior knowledge. Although developed several decades ago, the DOI theory remains one of the most widely applied theoretical frameworks for explaining agricultural technology adoption and innovation diffusion [26, 6].

The DOI theory posits that farmers acquire knowledge of agricultural innovations through formal and informal communication channels, including agricultural extension services, research institutions, farmer organizations, demonstration plots, social networks, and mass media. Following awareness, farmers assess the innovation based on its perceived relative advantage, compatibility, complexity, trialability, and observability, which subsequently influence their adoption decisions [34]. Recent empirical evidence demonstrates that information access, extension contact, farmer training, and social learning remain among the strongest drivers of agricultural technology adoption across developing countries [6, 32]. Likewise, Rizzo et al. [33], in a systematic review of sustainable agricultural innovations, concluded that effective knowledge dissemination and institutional support are critical for accelerating farmers' adoption of improved technologies.

The DOI theory provides an appropriate conceptual foundation for this study because awareness and adoption of improved cassava varieties are inherently sequential processes. Farmers must first become aware of improved cassava varieties before they can evaluate their agronomic and economic benefits and subsequently decide whether to adopt them. Consequently, awareness is unlikely to be randomly distributed among farmers but is influenced by socioeconomic characteristics and institutional factors such as education, farming experience, extension contact, cooperative membership, access to credit, and farm size. These factors not only determine farmers' exposure to improved cassava varieties but also shape their subsequent adoption behaviour.

This theoretical perspective is consistent with the awareness–adoption framework proposed by Diagne and Demont [10], who demonstrated that conventional adoption models may produce biased estimates when they fail to distinguish between farmers who are unaware of an innovation and those who are aware but choose not to adopt it. Their framework established that awareness is a prerequisite for adoption and should therefore be explicitly incorporated into empirical analyses of agricultural technology adoption. This proposition has received considerable

empirical support in cassava production systems. For example, Afolami et al. [5] found that farmers' awareness significantly influenced the adoption of improved cassava varieties in southwestern Nigeria, emphasizing the central role of extension services and information dissemination in promoting varietal diffusion.

The DOI theory therefore provides the theoretical justification for the empirical strategy adopted in this study. Consistent with the innovation-decision process described by Rogers [34], awareness of improved cassava varieties constitutes the initial stage of technology diffusion, while adoption represents the subsequent behavioural outcome. Since awareness is endogenous to the adoption process, the Endogenous Switching Poisson Regression model is employed to jointly estimate awareness and adoption decisions, thereby accounting for potential selection bias and generating consistent estimates of the determinants of adoption intensity. Consequently, the conceptual framework underpinning this study links information and institutional factors to farmers' awareness, awareness to adoption decisions, and adoption to improved agricultural productivity and household welfare.

Conceptual framework

The conceptual framework as shown in Figure 1 illustrates the pathways through which farmer and farm characteristics, together with information and institutional sources, influence farmers' awareness and subsequent adoption of improved cassava varieties in Ogun State, Nigeria. The framework is anchored on the premise that awareness is a prerequisite for adoption, and that adoption decisions are conditional upon farmers first becoming aware of the technology.

At the first stage, farmers' awareness of improved cassava varieties is determined by a combination of socioeconomic and farm-level characteristics, including age, education, farming experience, household size, farm size, extension contact, access to credit, cooperative membership, market access, distance to input sources, and the sex of the household head. In addition, awareness is shaped by information and institutional sources, such as agricultural extension services, research institutions, farmer organizations and cooperatives, fellow farmers and social networks, and mass media and digital platforms. These channels serve as the primary mechanisms through which knowledge about improved cassava varieties is disseminated to farming households.

The framework recognizes that awareness is endogenous rather than randomly distributed among farmers. Farmers with better access to information, institutional support, or favourable socioeconomic characteristics are more likely to become aware of improved varieties. Ignoring this non-random selection into awareness may lead to biased estimates of adoption behaviour because the same unobserved factors influencing awareness may also affect adoption decisions.

To account for this awareness-adoption gap, the study employs the Endogenous Switching Poisson Regression (ESPR) model. The first component of the ESPR estimates the selection equation, which models the probability that a farmer is aware of improved cassava varieties. Based on the outcome of this stage, farmers are separated into two groups: those who are aware and those who are not. Only farmers who are aware are assumed to have the opportunity to make an adoption decision.

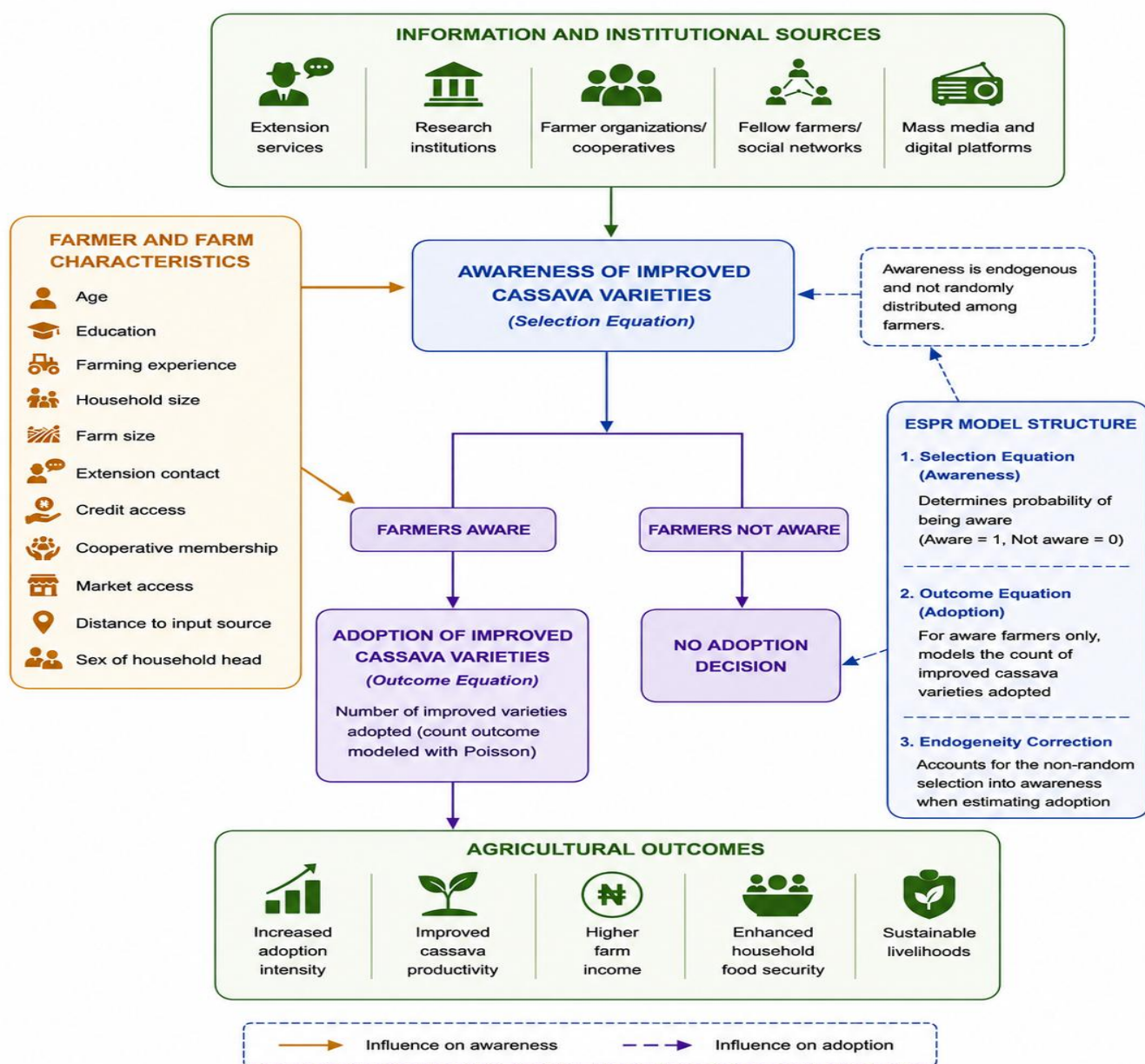


Fig 1. Conceptual framework linking awareness to adoption

The second component of the framework models the adoption equation, where the outcome is measured as the number of improved cassava varieties adopted. Because adoption is represented as a count variable, the adoption intensity among aware farmers is estimated using a Poisson regression model. Farmers who are not aware are excluded from the adoption decision because they cannot adopt technologies they do not know exist. This distinction explicitly captures the awareness-adoption gap that characterizes the diffusion of agricultural technologies.

Finally, the framework links adoption of improved cassava varieties to agricultural outcomes. Increased adoption intensity is expected to improve cassava productivity, raise farm income, strengthen household food security, and enhance sustainable livelihoods. By modelling

awareness and adoption jointly while correcting for endogenous selection into awareness, the ESPR framework provides a more reliable assessment of the determinants of improved cassava variety adoption and highlights the critical role of information access and institutional support in promoting agricultural technology uptake among cassava farmers in Ogun State.

Materials and methods

Description of the study area

The study was conducted in Ogun State in the Southwestern region of Nigeria. The State lies between latitudes 6°N and 8°N and longitudes 3°E and 5°E. Bordered by the Republic of Benin to the west, Ondo State to the east, Oyo State to the north, and Lagos State and the Atlantic Ocean to the south, Ogun State spans approximately 16,762 square kilometers, approximately 1.81% of Nigeria's landmass [11].



Fig 2. Map of Ogun State

Traditionally, the State is agrarian, producing crops such as maize, cassava, yam, rice, cocoa, rubber, and palm kernel. Fish farming and lumbering also thrive because of the abundance of waterways and forest resources [11]. Urban and rural residents engage in trade, industry, and public services. The state's proximity to Lagos and Ibadan has enhanced its commercial and industrial development, including sectors such as food processing, textiles, chemicals, and metal products. Ogun State is divided into four agricultural zones (Ilaro (Yewa), Abeokuta (Egba),

Ikenne (Remo), and Ijebu Ode (Ijebu)) by the Ogun State Agricultural Development Programme [27].

Sampling technique and sampling size

A multistage sampling procedure was used for this study; the first stage involved a purposive selection of Ijebu East and Ijebu North-East Local Government Areas (LGA) out of the 20 Local Government Areas in the state due to the massive production of cassava in these areas; the second stage was a random selection of six cassava producing wards from each of the 10 political wards in the LGAs, and the third involved a purposive selection of two communities from each selected ward on the basis of the presence of cassava farmers within the community. The final stage involved random selection of 12 cassava farmers from each of the selected communities making a total sample size of 288 cassava farmers. However, only 274 observations were fit for the data analysis. This represents 95.1% response rate. Primary data were used in this study, and the data collected were analyzed using descriptive statistics and an endogenous switching Poisson regression (ESPR) model.

Ethical clearance for this study was obtained from the Postgraduate Committee of Michael Okpara University of Agriculture (MOUAAU), Nigeria. Written informed consent was obtained from all participants prior to data collection. Participants were informed of the study purpose, voluntary nature of participation, and their right to withdraw at any time without penalty.

Endogenous switching Poisson regression (ESPR) model

This study employed the Endogenous Switching Poisson Regression (ESPR) model to analyze the factors influencing cassava farmers' awareness and uptake of improved cassava varieties in Ogun State, Nigeria. The choice of the ESPR model is informed by the nature of the outcome variable and the potential endogeneity associated with farmers' awareness of the improved cassava varieties. Specifically, awareness is treated as an endogenous selection variable, while the number of improved cassava varieties adopted is specified as the outcome variable, measured in count form. Since the adoption variable represents the number of improved cassava varieties adopted by farmers, the Poisson framework is appropriate for modelling non-negative integer outcomes [12]. However, awareness and adoption decisions are likely to be jointly determined by observable and unobservable factors, thereby necessitating an endogenous switching framework to correct for selection bias and endogeneity.

The conventional Poisson regression model assumes the exogeneity of explanatory variables and fails to account for selection bias arising from farmers' self-selection into awareness status. Farmers who are aware of improved cassava varieties may systematically differ from those who are unaware of both observed and unobserved characteristics, such as managerial ability, access to information, innovativeness, and social networks. Failure to control for endogeneity may produce biased and inconsistent parameter estimates [21]. The endogenous switching regression framework addresses this concern by jointly estimating the awareness equation and adoption outcome equations under different regimes while accounting for the correlation between the error terms of the selection and outcome equations [22, 21].

The ESPR framework is particularly suitable in agricultural technology adoption studies because farmers' awareness of improved technologies often conditions their adoption behavior. Several empirical studies have applied endogenous switching regression approaches in agricultural technology adoption analyses to account for both observable and unobservable heterogeneity between adopters and non-adopters [2, 9, 14].

The analytical framework assumes that a farmer first decides whether to become aware of improved cassava varieties. Conditional on awareness status, the farmer decides the number of improved cassava varieties to adopt. The awareness decision is modeled as a latent variable, specified as: $A_i^* = X_i \alpha + \varepsilon_i$ (1)

where:

A_i^* is the latent variable representing the propensity of the i^{th} farmer to be aware of improved cassava varieties,

X_i is a vector of explanatory variables influencing awareness;

α is a vector of the parameters to be estimated; and

ε_i is the random error term.

The observed awareness status is defined as:

$$A_i = \begin{cases} 1, & \text{if } A_i^* > 0 \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

Farmers who are aware of improved cassava varieties constitute one regime, whereas those who are not aware constitute the alternative regime. Conditional on the awareness status, the adoption outcome equations are specified using Poisson regression models. For farmers aware of improved cassava varieties

$$Y_{1i} = X_{1i} \beta_1 + \mu_{1i} \quad , \quad \text{if } A_i = 1 \quad (3)$$

For farmers who are not aware of improved cassava varieties:

$$Y_{0i} = X_{0i} \beta_0 + \mu_{0i} \quad , \quad \text{if } A_i = 0 \quad (4)$$

Y_{1i} and Y_{0i} represent the number of improved cassava varieties adopted under the aware and non-aware regimes respectively;

X_{1i} and X_{0i} are vectors of explanatory variables affecting adoption;

μ_{1i} and μ_{0i} are stochastic disturbance terms.

As the dependent variable is count-based, the conditional mean of adoption is modeled using the Poisson specification:

$$E(Y_i / X_i) = \exp(X_i \beta) \quad (5)$$

The error terms (ε_i , μ_{1i} , μ_{0i}) were assumed to follow a trivariate normal distribution with zero means and a non-zero covariance structure. The presence of significant covariance terms indicates endogenous switching arising from selection bias. The Full Information Maximum Likelihood (FIML) estimation procedure is employed to jointly estimate the selection and outcome equations simultaneously because it produces efficient and consistent estimates under endogenous switching conditions [21].

The empirical specification of the awareness equation is therefore expressed as:

$$A_i^* = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \dots + \alpha_n X_n + \varepsilon_i \quad (6)$$

Similarly, the adoption outcome equations are specified as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + \varepsilon_i \quad (7)$$

where:

X₁= age of household heads (years).

X₂= sex (1=male, 0=otherwise).

X₃= household size (number of persons).

X₄= marital status (1=married, 0=otherwise).

X₅= income from secondary occupation (₦).

X₆= years of formal education (years).

X₇= cooperative membership (1=member, 0=otherwise).

X₈= membership of farmers' association (1=member, 0=otherwise).

X₉= ownership of farmland (1=own farmland, 0=otherwise).

X₁₀= farming experience (years).

X₁₁= credit access (1=had access, 0=otherwise).

X₁₂= extension contact (number of contacts).

X₁₃= access to improved farm inputs (1=had access, 0=otherwise), and

X₁₄= area of farmland cultivated (hectare).

3 Results

Socioeconomic attributes of the cassava farmers

The results of the distribution of the socioeconomic attributes of cassava farmers are presented in Table 1. The average age of cassava farmers was approximately 47 ± 12.85 years, indicating that most farmers are within their productive age, which may positively influence their ability to adopt new cassava farming practices. This finding is consistent with Abdoulaye et al. [1], who reported that most cassava farmers in Nigeria fall within the 41–60 years age range. About 64% of the cassava farmers were male, indicating male dominance in cassava production. This may be attributed to the energy-intensive nature of cassava production, which is often more readily undertaken by men, as well as their greater responsibility for household provisioning. These findings align with Ojeleye et al. [28] and Mato et al. [23]. The gender disparity may also be linked to differential access to productive assets such as land, which tends to favour men [5].

The mean household size was approximately 6 ± 2.01 persons, suggesting relatively large household sizes that may enhance labour availability and support adoption of improved cassava varieties. This is consistent with typical household sizes reported in Nigeria, although it is lower than the 11–15 members reported by Mato et al. [23] in Abuja. About 91% of the farmers were married, which may be associated with greater household labour availability, as family members are often engaged in farm activities [1, 5, 23]. The average monthly income from non-cassava activities was ₦25,208.07 $\pm$ ₦4,908.46. This additional income may enhance financial capacity for technology adoption, although it may also reduce reliance on cassava production.

The average years of formal education was approximately 4 ± 4.46 years, indicating generally low educational attainment among cassava farmers. This aligns with Mato et al. [23], who reported that most cassava farmers in Abuja had only primary education. Low education levels may constrain farmers' ability to access and process information on improved technologies. About 25% of farmers belonged to cooperative associations, a relatively low proportion compared with Mato et al. [23], suggesting limited access to collective resources such as credit and inputs,

which may negatively affect adoption. However, 41% belonged to farmers' associations, which may enhance awareness and diffusion of improved practices.

About 74% of the farmers owned the land they cultivated, suggesting secure land tenure that may encourage experimentation with improved cassava varieties. This is consistent with Mato et al. [23] but contrasts with Ojeleye et al. [28], who found no significant effect of ownership on adoption. The average farming experience was approximately 18 ± 9.81 years, indicating substantial experience in cassava farming. This aligns with John and Johnny [15] and Mato et al. [23], and suggests that farmers may rely heavily on past experience, potentially limiting openness to new technologies.

Access to credit was low (23%), which may constrain farmers' ability to invest in improved practices. Similarly, only 41% had access to extension services, indicating limited exposure to agricultural innovations, although extension contact is generally associated with higher adoption [28]. About 44% of farmers were aware of improved cassava varieties, implying that a majority remain unaware of available technologies, which may limit adoption [5]. In addition, only 38% had access to improved farm inputs such as cassava stems, fertilizers, herbicides, and pesticides, which may further constrain adoption due to input scarcity.

Finally, the average farm size was 2.37 ± 1.05 hectares, indicating that most cassava farmers are smallholders. This may limit their ability to experiment with improved varieties on a large scale, thereby constraining adoption of new technologies.

Table 1. Demographic attributes of the cassava farmers

Variable	Mean	Std. Dev.	Min	Max
Age	46.62	12.85	0	78
Sex	0.64	0.48	0	1
Household size	5.90	2.01	2	14
Marital status	0.91	0.28	0	1
Income from secondary occupation	25208.07	4908.46	0	250000
Years of formal education	4.08	4.46	0	14
Cooperative membership	0.25	0.43	0	1
Membership of farmers association	0.41	0.49	0	1
Ownership of farmland	0.74	0.44	0	1
Farming experience	17.47	9.81	3	50
Credit access	0.23	0.42	0	1
Extension contacts	0.41	0.49	0	1
Awareness of new cassava varieties	0.44	0.50	0	1
Access to improved farm inputs	0.38	0.49	0	1
Area of farmland cultivated	2.37	1.05	0.2	5

Source: Field Survey Data Analysis, 2026.

Awareness of improved cassava varieties

The results on farmers' awareness of improved cassava varieties are presented in Table 2. Among the improved varieties, TME 419 recorded the highest level of awareness, with 37.23% of the farmers indicating that they were aware of the variety. This was followed by TMS 98/0505 (29.93%), TMS 30572 (24.09%), and TMS 98/0581 (19.71%), while TMS 01/1368 had the lowest awareness level at 6.57%. Overall, awareness of the improved cassava varieties remained low

across all the varieties considered, indicating that a substantial proportion of cassava farmers had limited knowledge of the available improved planting materials.

The generally low level of awareness suggests inadequate dissemination of information on improved cassava varieties through extension services, farmer organizations, and other agricultural information channels. Limited awareness is likely to constrain adoption because farmers cannot evaluate or adopt technologies of which they have no knowledge. This finding supports the awareness–adoption hypothesis of agricultural technology diffusion, which posits that awareness is a necessary prerequisite for adoption. The result is consistent with [10], who argued that failure to distinguish between awareness and adoption may lead to biased estimates of adoption rates because farmers who are unaware of an innovation cannot be considered potential adopters. Similarly, the finding corroborates [5], who reported that awareness significantly influenced the adoption of improved cassava varieties among rural households in southwestern Nigeria, emphasizing the importance of effective information dissemination and extension services in promoting technology uptake. Consequently, strengthening extension delivery systems, farmer-based organizations, demonstration activities, and other communication platforms is essential for improving awareness and accelerating the adoption of improved cassava varieties among smallholder farmers in Ogun State.

Table 2. Awareness of improved cassava varieties

Variable	Frequency*	Proportions (n=274)
TME 419	102	37.23
TMS 98/0505	82	29.93
TMS 98/0581	54	19.71
TMS 30572	66	24.09
TMS 01/1368	18	6.57

Source: Field Survey Data Analysis, 2026.

* Indicates multiple responses

Adoption of improved cassava varieties

The results on the adoption of improved cassava varieties are presented in Table 3. The findings indicate that TME 419 was the most widely adopted improved variety, with 17.88% of farmers cultivating it. However, this adoption rate is substantially lower than the 60.2% and 60.6% reported among cassava farmers in Ogun/Osun and Ondo States, respectively, by [5] and [29]. Similarly, 12.77% of the respondents adopted TMS 98/0505, which is slightly higher than the 10.3% reported by [5] for southwestern Nigeria. Adoption of TMS 98/0581 and TMS 30572 remained low at 8.03% and 8.39%, respectively, while TMS 01/1368 recorded the lowest adoption rate of only 1.82%.

Overall, adoption of improved cassava varieties was generally low across all varieties considered, despite the availability of these technologies. The low adoption levels suggest that awareness alone is insufficient to stimulate widespread uptake, as farmers may continue to face constraints such as limited access to planting materials, inadequate extension support, financial limitations, and risk aversion. This finding reinforces the view that technology adoption is influenced by both informational and institutional factors rather than awareness alone. Similar observations have been reported in previous studies, which found that although improved cassava varieties offer significant productivity and welfare benefits, their adoption remains constrained by

socioeconomic and institutional barriers [5, 20, 28, 31]. The findings underscore the need to strengthen extension services, improve farmers' access to certified planting materials and agricultural credit, and promote farmer-based organizations to accelerate the diffusion and adoption of improved cassava varieties.

Table 3. Adoption of improved cassava varieties

Variable	Frequency*	Proportions (n=274)
TME 419	49	17.88
TMS 98/0505	35	12.77
TMS 98/0581	22	8.03
TMS 30572	23	8.39
TMS 01/1368	5	1.82

Source: Field Survey Data Analysis, 2026.

* Indicates multiple responses

Distribution of number of improved cassava varieties adopted by the farmers

As shown in Figure 1, the kernel density estimates of the number of improved cassava varieties adopted reveal a highly right-skewed distribution, indicating that adoption is concentrated at the lower end. The density peaks sharply around zero, showing that a large proportion of smallholder farmers adopt no or very few improved cassava varieties. This suggests a generally low adoption intensity within the study area.

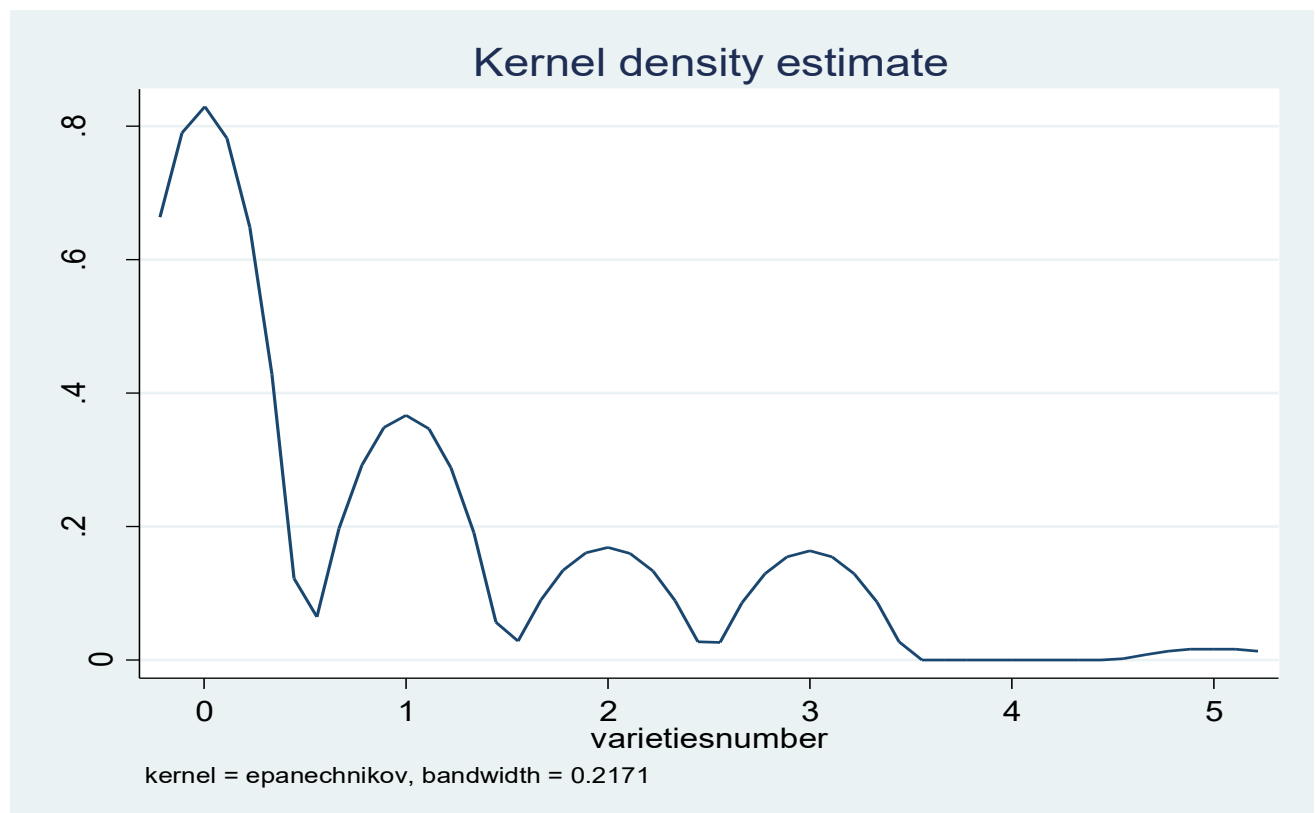


Fig 3. Kernel density estimate of improved cassava varieties adopted

Source: Field Survey Data Analysis, 2026.

A noticeable but smaller peak around one variety indicates that some farmers are beginning to adopt improved cassava technologies. However, adoption remains limited and not diversified. The density steadily declined as the number of varieties increased from two to five, reflecting that only a small fraction of farmers adopted multiple improved cassava varieties simultaneously. This pattern highlights that, while awareness or initial adoption may exist, broad and sustained adoption across several varieties is uncommon. The presence of a long, thin right tail confirms that very few farmers are high adopters, experimenting with a wider range of improved varieties. These farmers are likely to have better access to resources such as improved stems, extension services, credit, or information networks, which enable them to diversify their adoption choices.

Factors influencing awareness and adoption of improved cassava varieties

The results of the endogenous switching regression of the factors influencing cassava farmers' awareness and uptake of improved varieties are presented in Table 4. The findings indicate that awareness of improved cassava varieties is truly endogenous, as shown by the significant Wald Chi-square statistic (85.12), which is significant at the 1% ($p < 0.01$) level. The correlation coefficient (ρ) between awareness and adoption was 0.949, which is positive and significant at the 1% level, indicating a strong positive association between awareness and adoption decisions. The model generated two sets of estimates: the first explains the determinants of awareness of improved cassava varieties, while the second explains the determinants of adoption of improved varieties, with awareness treated as an endogenous variable. The average treatment effect (ATE) indicates that, on average, farmers would adopt about 72.4% more improved cassava varieties if they were aware of them. Similarly, the average treatment effect on the treated (ATET) shows that farmers who were aware of improved varieties would have adopted about 61.1% more varieties had they not been aware, highlighting the substantial role of awareness in adoption intensity.

The results of the Endogenous Switching Poisson Regression model are presented in Table 4. The findings indicate that age has a negative and statistically significant effect ($p < 0.01$) on both farmers' awareness and adoption of improved cassava varieties. This suggests that older farmers are less likely to become aware of or adopt improved varieties, possibly because they rely more on established farming practices and are generally less receptive to new technologies. This finding contrasts with those of Abdoulaye et al. [1] and Syafrial et al. [36], who reported no significant relationship between age and adoption.

Household size exerts a negative effect on awareness ($p < 0.10$) but a positive effect on adoption ($p < 0.01$). This implies that farmers from larger households are less likely to be aware of improved cassava varieties, yet, once aware, they are more likely to adopt them. The greater household labour availability and the need to enhance food production and household income may explain this positive adoption effect. This finding differs from the results reported by Abdoulaye et al. [1] and Mato et al. [23], who found no significant influence of household size on adoption.

Marital status positively and significantly influences awareness ($p < 0.001$), indicating that married farmers are more likely to be aware of improved cassava varieties than their unmarried counterparts. This may reflect stronger social networks and greater participation in community and agricultural activities, which enhance access to agricultural information. In contrast, income from secondary occupations negatively affects adoption ($p < 0.01$), suggesting that farmers with alternative income sources are less dependent on cassava production and therefore less inclined to invest in improved cassava varieties. This finding is consistent with Afolami et al. [5].

The results further reveal that education positively and significantly influences adoption ($p < 0.01$), indicating that farmers with higher levels of formal education are more likely to adopt

improved cassava varieties because they are better able to acquire, process, and utilize agricultural information. This finding is consistent with Mato et al. [23]. Similarly, farming experience positively affects awareness ($p < 0.10$), suggesting that experienced farmers are more likely to have encountered information on improved varieties through years of engagement in cassava production. However, its negative, though statistically insignificant, coefficient in the adoption equation suggests that experienced farmers may remain attached to conventional production practices despite being aware of improved technologies. This finding supports Ojo and Ogunyemi [29] but contrasts with Afolami et al. [5].

Table 4. ESPR estimates of factors influencing awareness and adoption of improved cassava varieties

	Coef.	Std. Err.	Z	Coef.	Std. Err.	z
Variable	Awareness of improved varieties			Adoption of improved varieties		
Age	-0.019***	0.007	-2.79	-0.024***	0.009	-2.58
Sex	0.030	0.203	0.15	0.244	0.271	0.90
Household size	-0.096*	0.05	-1.90	0.249***	0.061	4.07
Marital status	2.078***	0.649	3.20	0.162	0.525	0.31
Income from secondary occupation	9.61E-07	2.07E-06	0.46	-7.84E-06***	2.41E-06	-3.25
Years of formal education	-0.026	0.026	-1.00	0.125***	0.036	3.47
Cooperative membership	0.072	0.181	0.40	0.005	0.245	0.02
Membership of farmers association	-0.063	0.21	-0.30	0.076	0.294	0.26
Ownership of farmland	-0.21	0.26	-0.81	0.059	0.321	0.18
Farming experience	0.020*	0.01	1.92	-0.019	0.012	-1.53
Credit access	0.069	0.222	0.31	0.272	0.323	0.84
Extension contacts	-0.422	0.274	-1.54	2.081***	0.326	6.39
Access to improved farm inputs	1.130***	0.236	4.79	0.616**	0.276	2.23
Area of farmland cultivated	-0.148	0.099	-1.50	0.200*	0.117	1.72
Awareness				0.722**	0.349	2.07
Constant	-2.598***	0.759	-3.42	-1.362*	0.734	-1.86
ATE	0.724	0.334	2.16			
ATET	0.611	0.323	1.89			
Diagnostic statistics						
/athrho	-1.819**	0.798	-2.28			
/lnsigma	-0.825**	0.417	-1.98			
Rho	0.949***	0.080				
Sigma	0.438	0.083				
Wald chi ² (15)	85.120***					
Prob > chi ²	0.000***					
Log likelihood	-403.388					
Number of obs	274					

Source: Field Survey Data Analysis, 2026.

***, ** and * indicate the variables are significant at 1%, 5% and 10% respectively

Institutional factors also play a significant role in technology uptake. Extension contact has a positive and highly significant effect on adoption ($p < 0.01$), highlighting the critical role of extension services in disseminating information, providing technical support, and encouraging the use of improved cassava varieties. This finding corroborates earlier studies by Abdoulaye et al. [1], Charles et al. [8], and Mato et al. [23]. Likewise, access to improved farm inputs significantly increases both awareness ($p < 0.01$) and adoption ($p < 0.05$), indicating that the availability of improved planting materials and complementary inputs facilitates both exposure to and utilization of improved cassava varieties. This result agrees with Afolami et al. [5].

Furthermore, farm size positively influences adoption ($p < 0.10$), implying that farmers operating larger farms are more likely to adopt improved cassava varieties because they possess greater production capacity and are better able to bear the risks associated with experimenting with new technologies. This finding is consistent with Mato et al. [23] and Ojeleye et al. [28]. Finally, awareness of improved cassava varieties has a positive and statistically significant effect on adoption ($p < 0.05$), confirming that awareness is a fundamental prerequisite for technology uptake. Farmers cannot adopt innovations of which they are unaware, emphasizing the importance of effective information dissemination in the adoption process. This finding provides empirical support for the awareness–adoption framework advanced by Diagne and Demont [10] and is consistent with evidence reported by Afolami et al. [5].

Discussion

This study provides empirical evidence on the awareness–adoption dynamics of improved cassava varieties in Ogun State, Nigeria, with particular attention to socioeconomic characteristics, varietal awareness and adoption patterns, and the role of endogeneity in farmers' decision-making processes. The findings contribute to the growing literature on agricultural technology adoption in Sub-Saharan Africa by demonstrating that awareness and adoption are jointly determined and structurally distinct behavioural stages.

The socioeconomic profile of cassava farmers indicates a relatively young and economically active farming population, with an average age of 47 years. This suggests that most farmers are still within their productive years and potentially capable of engaging with improved agricultural technologies. This finding aligns with Abdoulaye et al. [1], who reported that cassava farming in Nigeria is dominated by middle-aged farmers. However, while productive age structure is generally expected to favour adoption, age was found in the ESPR results to negatively influence both awareness and adoption, suggesting that accumulated experience may reinforce reliance on traditional practices and reduce openness to new technologies. This supports Syafril et al. [36] and contrasts with studies that found no significant effect of age on adoption behaviour. The dominance of male farmers (64%) reflects gendered access to productive resources in cassava production systems. This pattern is consistent with Ojeleye et al. [28] and Mato et al. [23], and may be explained by gender disparities in access to land and labour-intensive farm activities, as noted by Afolami et al. [5]. The implication is that structural inequalities in resource access continue to shape participation in cassava production systems and may indirectly influence technology uptake.

Household structure also plays a significant role in production decisions. The average household size of six members suggests relatively large family labour availability, which may reduce labour constraints associated with cassava production. Interestingly, the ESPR results indicate that larger households are less likely to be aware of improved cassava varieties but more likely to adopt them. This apparent paradox suggests that while information constraints may limit

awareness formation, labour availability and consumption needs may encourage adoption once awareness is achieved. This finding contradicts Abdoulaye et al. [1] and Mato et al. [23], highlighting the importance of distinguishing between awareness and adoption stages. Marital status was positively associated with awareness, suggesting that married farmers may benefit from broader social networks and information exchange, which enhances exposure to agricultural innovations. This reinforces the role of social embeddedness in technology diffusion processes in rural farming systems. Education emerged as a key determinant of adoption behaviour. Farmers with more years of formal education were more likely to adopt improved cassava varieties, consistent with Mato et al. [23]. Education enhances cognitive ability, information processing, and risk evaluation, thereby improving decision-making under uncertainty. However, the relatively low average education level (approximately four years) indicates limited capacity for technical interpretation of improved agricultural information, which may slow the diffusion of innovation.

Institutional variables further explain adoption constraints. Low cooperative membership (25%) and moderate participation in farmer associations (41%) suggest weak collective action structures. These institutions are critical for credit access, input distribution, and information sharing. Similarly, limited access to credit (23%) constrains farmers' liquidity and reduces their ability to invest in improved technologies. These findings reinforce earlier evidence that financial and institutional constraints remain major barriers to agricultural technology uptake in Nigeria. Farm ownership (74%) and an average farm size of 2.37 hectares indicate that cassava production is largely smallholder-based. While land ownership is expected to encourage investment in long-term technologies, the small farm size may limit experimentation and mechanisation, thereby constraining large-scale adoption of improved varieties. Farming experience was found to increase awareness but not necessarily adoption, suggesting that experiential knowledge may enhance exposure but simultaneously reinforce conservative production behaviour, as also observed by Ojo and Ogunyemi [29].

The descriptive results on awareness levels show generally low exposure to improved cassava varieties. Awareness rates for specific varieties such as TME 419 (37.23%) and TMS 98/0505 (29.93%) remain modest, while awareness of other varieties is even lower. This confirms that information dissemination remains incomplete and uneven across farming communities. Consistent with Diagne and Demont [10] and Afolami et al. [5], the results reaffirm that awareness is a prerequisite for adoption but is not sufficient in itself to guarantee uptake. Adoption rates are even lower than awareness levels across all varieties. TME 419 recorded the highest adoption (17.88%), yet this remains far below reported regional benchmarks. The relatively higher adoption of TME 419 may be attributed to its agronomic advantages, including higher yield potential, disease resistance, and lower moisture content. However, the overall low adoption rates across all varieties indicate persistent constraints beyond awareness, including limited access to improved planting materials, financial limitations, and institutional inefficiencies.

The ESPR results provide strong evidence that awareness is endogenous in the adoption process. The significant Wald chi-square statistic confirms the joint determination of awareness and adoption decisions, while the high positive correlation coefficient ($\rho = 0.949$) indicates strong interdependence between both stages. This justifies the use of an endogenous switching framework and confirms that ignoring selection effects would produce biased estimates. The estimated treatment effects further demonstrate the critical role of awareness in technology uptake. The average treatment effect suggests that farmers would adopt approximately 72.4% more improved cassava varieties if they were aware of them, while the average treatment effect on the treated (ATET) indicates a 61.1% increase among already aware farmers under counterfactual conditions.

These results highlight awareness as a major binding constraint in the adoption pathway and reinforce the importance of effective information dissemination mechanisms.

The determinants of awareness and adoption further confirm the dual-stage nature of farmers' decision-making. Extension contacts significantly increased adoption, consistent with Abdoulaye et al. [1], Charles et al. [8], and Mato et al. [23], highlighting the importance of agricultural advisory services in reducing information asymmetry and promoting technology uptake. Similarly, access to improved inputs positively influenced both awareness and adoption, confirming that input delivery systems serve as important channels for both information dissemination and technology diffusion. Farm size positively influenced adoption, indicating that farmers operating larger farms possess greater capacity to experiment with and absorb the risks associated with improved technologies, consistent with Ojeleye et al. [28]. Conversely, higher income from non-farm activities reduced the likelihood of adoption, suggesting labour reallocation away from agriculture and reduced dependence on cassava production as a primary livelihood source. Importantly, awareness itself significantly increased the probability of adoption, reinforcing its role as a necessary prerequisite for technology uptake. This finding aligns with Diagne and Demont [10] and confirms that policy interventions aimed at increasing farmers' awareness can generate substantial improvements in the adoption of improved cassava varieties.

Conclusions

This study was carried out to estimate the factors influencing awareness and adoption of improved cassava varieties while addressing the endogeneity between awareness and adoption using endogenous switching Poisson regression. Awareness of improved cassava varieties was considered endogenous, while adoption was considered as the outcome variable. The findings revealed that most of the cassava farmers were male, married, within their productive age, and had a large household size. It was also revealed that most of the farmers had a basic education, did not belong to cooperative or farmers associations, and did not own their farmlands. Furthermore, most farmers did not have access to credit facilities, and less than half of the farmers did not have contact with extension agents or were aware of new cassava varieties.

The results revealed that TME 419 had the highest awareness and adoption rate, although there is an awareness-adoption gap: 44% of farmers were aware of improved varieties, yet only 17.88% adopted TME 419. The study found that the awareness of cassava farmers was influenced by the age of household heads, marital status, farming experience, and access to improved farm inputs. Similarly, the adoption of improved cassava varieties was influenced by age, household size, income from secondary occupations, years of formal education, extension contact, access to improved farm inputs, area of farmland cultivated, and awareness. The counterfactual treatment effects further reveal asymmetry in adoption gains. Adopters would have recorded 72.4% lower adoption intensity had they not adopted while non-adopters would have increased adoption intensity by 61.1% if they had adopted. This suggests the existence of unobserved constraints that prevents non-adopters from translating awareness into adoption despite their potential gains.

The study concluded that an increase in awareness, being a member of a cooperative association, contact with extension agents, access to improved farm inputs, and increasing the area of farmland cultivated will increase the adoption of improved cassava varieties. To increase the adoption of new varieties among cassava farmers, the study recommends that policy intervention must move beyond generic awareness creation to bundled, adoption-focused strategies. First,

extension services should be strengthened by reducing the extension-farmer ratio and training agents on varietal specific information to facilitate farmer trial and learning. Second, access to certified planting materials and credit must be improved as input constraints remain binding for adoption. Third, cooperative membership should be promoted to lower transaction costs and enhance collective access to information and input. Lastly, policies that discourage land fragmentation and support consolidation should be encouraged, as larger cultivated area increase adoption intensity. Without addressing these adoption-specific barriers, investment in cassava varietal development will continue to yield suboptimal returns at the farm level.

Author contributions

(A) Mr. Kazeem Aboaba, (B) Dr. Ayi Nsa, (C) Dr., (D) Dr. Florence Nse-Nelson, Dr. Taofeeq Amusa, (E) Dr. Ndidiamaka Ekweanya supported the work by supervising from the beginning, assisted in the field work, and edited the manuscripts. All authors reviewed the manuscripts.

Consent for publication

Consent to Publish Declaration was obtained from all the participants involved in the study. All authors have read and approved the final version of the manuscript and consented to its publication.

Data availability

The data will be made available upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and the research ethics guidelines of Michael Okpara University of Agriculture, Umudike (MOUUAU), Nigeria. The research protocol, survey instrument, and data collection procedures were reviewed and approved by the Postgraduate Committee of the Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, prior to field implementation. The Postgraduate Committee does not issue formal ethics approval reference or permit numbers for postgraduate survey-based research; therefore, no approval number is available for this study. Participation in the study was entirely voluntary. All respondents were informed of the objectives of the research, the nature of their participation, and their right to decline participation or withdraw at any time without penalty. Informed consent was obtained from all participants prior to data collection, and all information collected was treated confidentially and used solely for academic and research purposes.

Competing interests

The authors declare that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors of this paper would like to especially thank the cassava farmers in the study area for their wholehearted cooperation, hospitality, and willingness to participate in the survey. The authors also appreciate the support and assistance provided by the agricultural extension experts and professionals working in the area.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Clinical Trial Number: not applicable

ORCID

Kazeem Aboaba: 0000-0002-9486-6758

Nsa Ayi: 0000-0001-6177-290X

Florence Nse-Nelson: 0009-0008-6168-6401

Taofeeq Amusa: 0000-0001-9383-4845

Ndidiamaka Ekweanya: 000-0001 – 89249037

References

1. Abdoulaye T, Abass A, Maziya-Dixon B, Tarawali G, Okechukwu R, Rusike J, Alene A, Manyong V, Ayedun B. Awareness and adoption of improved cassava varieties and processing technologies in Nigeria. *J Dev Agric Econ*. 2014;6(2):67-75.
2. Abdulai A, Huffman W. The adoption and impact of soil and water conservation technology: an endogenous switching regression application. *Land Econ*. 2014;90(1):26-43.
3. Acheampong PP, Addison M, Wongnaa CA. Assessment of impact of adoption of improved cassava varieties on yields in Ghana: an endogenous switching approach. *Cogent Econ Finance*. 2022;10(1):2008587.
4. Adetula AI, Amos TT, Oparinde LO. Analysis of improved cassava varieties' cultivation and downside risk exposure among farmers in Ondo State, Nigeria. *Sci Pap Ser Manag Econ Eng Agric Rural Dev*. 2020;20(3):33-44.
5. Afolami CA, Obayelu EA, Vaughan II. Welfare impact of adoption of improved cassava varieties by rural households in South Western Nigeria. *Agric Food Econ*. 2015;3:18.
6. Ahn J, Myers BE, Warner LA, Diaz J, Lamino P. Revisiting Everett M. Rogers: a systematic review and random forest analysis of technology adoption in modern agriculture. *Adv Agric Dev*. 2026;7(2):8-22.
7. Arowosegbe OB, Alomaja OA, Tiamiyu BB. The role of agricultural extension workers in transforming agricultural supply chains: enhancing innovation, technology adoption, and ethical practices in Nigeria. *World J Adv Res Rev*. 2024;23(3):2585-2602.
8. Charles U, Ugbo C, Muojiana SO, Eze S. Agronomic evaluation of new varieties of cassava (*Manihot esculenta* Crantz) under different rates and modes of NPK (12-12-17-2) fertilizer application in two seasons. *Not Sci Biol*. 2018;10(1):14-18.
9. Di Falco S, Veronesi M, Yesuf M. Does adaptation to climate change provide food security? A micro-perspective from Ethiopia. *Am J Agric Econ*. 2011;93(3):829-846.
10. Diagne A, Demont M. Taking a new look at empirical models of adoption: average treatment effect estimation of adoption rates and their determinants. *Agric Econ*. 2007;37(2-3):201-210.
11. Dibiazue ZO. *Ogun* [Internet]. 2026 [cited 2026 Apr 9]. Available from: <https://www.zodml.org/discover-nigeria/states/ogun-state>
12. Greene WH. *Econometric Analysis*. 7th ed. Upper Saddle River (NJ): Pearson Education; 2012.

13. Ifeanyi-Obi CC, Uloh CO. Awareness and utilization of improved cassava varieties among female cassava-based farmers in Ikwerre Local Government Area, Rivers State, Nigeria. *Indian Res J Ext Educ.* 2025;25(2-3):24-33.
14. Jaleta M, Kassie M, Marennya P. Impact of improved maize variety adoption on household food security in Ethiopia: an endogenous switching regression approach. In: *Proceedings of the International Conference of Agricultural Economists*; 2015 Aug 8-14; Milan, Italy. Addis Ababa (ET): International Maize and Wheat Improvement Center (CIMMYT); Nairobi (KE): CIMMYT.
15. John HA, Johnny M. The role of farming experience on the adoption of agricultural technologies: evidence from smallholder farmers in Uganda. *J Dev Stud.* 2014;50(1):666-679.
16. Kamara AY, Adesiyun AT, Oyinbo O, Ajeigbe HA, Ignatius AI, Oluwale TS. Improving the productivity and income of smallholder sorghum farmers: the role of improved crop varieties in Nigeria. *Food Energy Secur.* 2025;14(1):e70058.
17. Karbo TV, Frewer L, Areal F, Jones G, Nurudeen S. A systematic review of the efficacy of theories used to understand farmers' technology adoption behavior in lower-to-middle-income countries. *Dev Stud Res.* 2024;11(1):2294696.
18. Kehinde DA, Akinola A. Modeling the dynamics of adoption intensity and disadoption of sustainable green packs among smallholder farmers in Northern Nigeria using a triple hurdle approach. *J Agric Food Res.* 2026;28:102961.
19. Kondo K, Cacho O, Fleming E, Villano RA, Asante BO. Dissemination strategies and the adoption of improved agricultural technologies: the case of improved cassava varieties in Ghana. *Technol Soc.* 2020;63:101408.
20. Kundiri MM, Bello OG, Mamman BY, Makinta U, Chamo AM, Kenneth AI. Socio-economic determinants of adoption of improved cassava varieties among crop farmers in ADP Zone I, Jigawa State, Nigeria. *J Agric Econ Environ Soc Sci.* 2022;8(1):20-32.
21. Lokshin M, Sajaia Z. Maximum likelihood estimation of endogenous switching regression models. *Stata J.* 2004;4(3):282-289.
22. Maddala GS. *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press; 1983.
23. Mato J, Fadiji TO, Ajah J, Sennuga SO. Factors influencing adoption of TME-419 cassava production by farmers in the Federal Capital Territory, Nigeria. *Indiana J Agric Life Sci.* 2025;5(4):7-14.
24. Mbanjo EGN, Rabbi IY, Ferguson ME, Kayondo SI, Eng NH, Tripathi L, Kulakow P, Egesi C. Technological innovations for improving cassava production in Sub-Saharan Africa. *Front Genet.* 2021;11:623736.
25. Mektel A, Mohammed A. Determinants of farmers' adoption decision of improved crop varieties in Ethiopia: systematic review. *Afr J Agric Res.* 2021;17(7):953-960.
26. Mesa-Manzano R, Esparcia J. Theoretical framework and methods for the analysis of the adoption-diffusion of innovations in agriculture: a bibliometric review. *Bol Asoc Geogr Esp.* 2023;96:e3336.
27. Ogun State Agricultural Development Programme. OGADEP monitoring visits by OGADEP management to Abeokuta zone [Internet]. 2026 [cited 2026 Apr 9]. Available from: <https://ogunadp.blogspot.com/>

28. Ojeleye OA, Ibrahim EA, Suleman R, Olorunfemi SD, Isah I. Factors affecting the adoption of improved cassava varieties in selected communities in Ajaokuta LGA, Kogi State, Nigeria. *Niger J Agric Ext.* 2017;18(3):2-7.
29. Ojo SO, Ogunyemi AI. Analysis of factors influencing the adoption of improved cassava production technology in Ekiti State, Nigeria. *Int J Agric Sci Nat Resour.* 2014;1(3):40-44.
30. Olayide OE, Obisesan D, Nitturkar H, Adesida A, Alegieunu B, Obisesan O. Cassava seedpreneurship, determinants of varietal adoption, profitability, and women empowerment in Nigeria. *Resour Environ Sustain.* 2021;6:100041.
31. Onyemma JO, Onyemauwa NC, Chioma UQ, Nwafor SC. Determinants of adoption of improved cassava technologies among farmers in Benue State, Nigeria. *Arch Curr Res Int.* 2020;20(8):10-22.
32. Park B, Kim T, An D, Mahasuweerachai P. Fostering innovation through farmer interactions: social networks and technology adoption. *J Agric Educ Ext.* 2026;32(3):409-430.
33. Rizzo G, Migliore G, Schifani G, Vecchio R. Key factors influencing farmers' adoption of sustainable innovations: a systematic literature review and research agenda. *Org Agric.* 2024;14:1-28.
34. Rogers EM. *Diffusion of Innovations*. 5th ed. New York (NY): Free Press; 2003.
35. Sseguya H, Robinson DS, Mwangi HR, Flock JA, Manda J, Abed R, Mruma SO. The impact of demonstration plots on improved agricultural input purchase in Tanzania: implications for policy and practice. *PLoS One.* 2021;16(1):e0243896.
36. Syafrial HT, Rahman MS, Retnoningsih D. The effects of improved cassava variety adoption on farmers' technical efficiency in Indonesia. *Asian J Agric Rural Dev.* 2021;11(4):269-278.
37. Taiwo OJ, Olasupo OA, Akindele EE, Igbatayo S, Dayo-Olagbende OG. The impact of the adoption of Dixon cassava variety on the poverty status and sustainable welfare of smallholder farmers in Oyo State, Nigeria. *Black Sea J Agric.* 2025;8(6):861-867.
38. Ukeje BA, Njoku ME, Agwu NA, Nkere C. Economic impact of adoption of cassava disease management technologies on income among male smallholder farmers in Southeast Nigeria: an endogenous switching regression approach. *Niger Agric J.* 2024;55(3):385-391.
39. Wiredu AN, Manda J, Feleke S, Asante BO, Savala CE, Kyei-Boahen S, Manyong V, Alene A. Impacts of quality seeds of improved legume varieties on incomes and poverty in Mozambique: an ordered choice endogenous switching regression analysis. In: *2021 Conference, International Association of Agricultural Economists*; 2021 Aug 17-31; Virtual. Paper No. 315294.