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Determinants of Maize Production Participation and Intensity among Rural Farming Households in Nigeria

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Abstract

Farmers' participation and production intensity in maize production are influenced by a combination of socioeconomic and production-related characteristics that shape their ability and willingness to produce. This study analyzed the determinants of farmers' participation and production intensity in maize production in Nigeria using data from the fifth wave of the General Household Survey cross-section, 2023/2024. The study employed descriptive statistics and the Cragg double-hurdle model for data analysis. The results showed that both participants and non-participants were predominantly male-headed and married households. Intercropping dominated maize production, accounting for 72.42% of participants, and production was predominantly market-oriented, with 89.06% of farmers producing mainly for sale. The double-hurdle results indicate that bank account ownership and access to main roads ($p < 0.05$), as well as residence in the North-West and South-South zones ($p < 0.01$) and the South-West zone ($p < 0.10$), significantly increase the likelihood of maize production participation. Production intensity among participants is negatively associated with age and positively influenced by hired labour ($p < 0.01$), herbicide quantity used ($p < 0.05$), household size ($p < 0.05$) and farm size ($p < 0.01$). The results indicate that the decision to participate in maize production is influenced by financial and infrastructural factors and regional location, whereas production intensity depends largely on farm size and input utilization.

Introduction

The importance of maize is well established given its role across the agricultural value chain, from production to marketing. As a staple crop, it supports millions of households and contributes to economic activities through food production, livestock feed and industrial use (Erenstein *et al.*, 2022). Maize is highly valued for its efficient use of sunlight, resulting in exceptional yield potential per hectare which makes it one of the most productive cereal crops in Nigeria (Awojoodu, 2020). Notably, in 2020, maize was cultivated on 6.048 million hectares, yielding an average of 2.56 tons per hectare, outperforming other major cereals such as sorghum, rice and millet (National Agricultural Extension and Research Liason Services (NAERLS) and Federal Ministry of Agriculture and Rural Development (FMARD), 2021). Recent studies indicate that maize has become the most widely cultivated cereal in Nigeria, with production and demand continuing to grow steadily (Wossen *et al*., 2023). However, despite this expansion, maize production is not without challenges. In Nigeria, factors such as limited access to land, labor, capital and credit; inadequate technology, climate-induced weather variability, declining soil fertility, digital and financial exclusion and recurrent farmer-herder conflicts create uncertainties in production decisions and productivity. These constraints are particularly evident across Nigeria's diverse agroecological zones,

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where variations in climate, land pressure, and institutional access influence maize production (Abiala and Blackwood, 2024; Olubunmi-Ajayi *et al*., 2024).

Given these constraints, understanding the factors separately influencing farmers' participation and production intensity in maize production requires an appropriate econometric modelling framework (Kelifa, 2023). According to Asfaw *et al*. (2022), the common approaches of modeling participation and production intensity are the Tobit, Heckman, and Double-hurdle models, with the latter employed for its ability to model independent decisions. The Tobit model jointly examines participation and intensity, assuming both are influenced by the same factors, which may lead to biased estimates. The Heckman model relaxes this assumption and corrects for selection bias but can be sensitive to small sample sizes, weak exclusion restrictions and strictly non-negative outcome (Otekunrin *et al*., 2019; Workie *et al*., 2025). The Double-hurdle model represents a two-stage decision-making framework generalizing the Tobit model, in which one stage governs the decision to participate and the other determines the level of participation, allowing each decision to function independently. Notably, the model accommodates zero observations in both stages, enhancing its flexibility (Derso *et al*., 2022). Although existing studies (Abdulmumini *et al*., 2024 and Mani *et al*., 2022), have examined the determinants of maize production participation and intensity, many have not modelled participation and production intensity as distinct decisions influenced by different socioeconomic, institutional, and production-related factors. This limits understanding of the true drivers of maize production behaviour and constrains the design of effective, context-specific policy interventions.

Following Dlamini and Huang (2019) we assumed, in this study, that the decisions on production participation and level of production intensity are influenced by different sets of independent variables. So, Cragg's double-hurdle model is relevant to this study. This study therefore, aimed to examine the socio-economic characteristics of maize-producing and non-producing household heads; and assess the determinants of participation in maize production and production intensity among participating households.

Materials and Methods

Scope of the study

This study was conducted in Nigeria, a West African country with approximately 70.8 million hectares of agricultural land, where major crops include maize, cassava, guinea corn (sorghum), yam, beans, millet, and rice. Agriculture remains a major component of the national economy, engaging about 70.0% of the active population (FAO, 2026).

Nigeria comprises 36 states and the Federal Capital Territory and is divided into six geopolitical zones: North-Central, North-East, North-West, South-East, South-South, and South-West. These zones differ in rainfall patterns, climate, vegetation, and soil characteristics, which influence agricultural systems and production decisions. Maize is a common staple cultivated across these agro-ecologies than other cereals and so contribute to food availability for Nigerian households.

Sampling Procedure and Sampling Size

Secondary data used for this study were sourced from the 2023/2024 Nigeria General Household Survey, administered by the National Bureau of Statistics in collaboration with the World Bank. The survey followed a two-stage stratified sampling procedure to ensure representativeness. In the first stage, Enumeration Areas (EAs) were selected using probability proportional to size, ensuring that larger population areas had a higher probability of selection.

In the second stage, households were systematically sampled within each selected EAs, maintaining a balanced and representative dataset. Farming households in Nigeria were identified using the crop code variable. The unit of analysis is individual farmers, captured through household heads engaged in crop production. A household was classified as a maize production participant if maize was cultivated on at least one plot during the reference period, either as a sole crop or under intercropping systems. Households without maize cultivation on any plot were classified as non-participants, although they remained active in the production of other crops. Information extracted from the dataset include socioeconomic and institutional characteristics such as age, sex, marital status, educational level, household size, access to credit, farm size and access to extension

services. Also, production information collected include, quantity of fertilizer, herbicide and hired labour employed by the household head and land size. After data cleaning, a total of 1615 maize producing and non-producing farmers was obtained.

Method of Data Analysis

Both descriptive and econometric statistical tools was used to analyze the data. Under descriptive analysis, mean, frequency, percentages and standard deviations were used. The econometric analysis used was the double-hurdle model, this was used to determine maize production participation and production intensity.

Theoretical Framework

Participation decisions are analyzed within a random utility framework, where choice-based outcomes are assumed to result from utility maximization (Hauser and Rao, 2002; Walisinghe and Gunaratne, 2012). Individuals are therefore assumed to choose the alternative that provides the highest expected utility (Maviko *et al.*, 2024) .

This study conceptualizes farmers' production participation as a discrete choice decision. Accordingly, a farmer is assumed to participate in maize production if the expected utility derived from producing maize exceeds the utility obtained from alternative production choices. The utility associated with maize production is latent and is influenced by household, farm, and institutional characteristics that shape expected benefits and costs. Consequently, factors such as access to land, labour availability, education, farming experience, access to credit, and production costs are expected to influence farmers' participation decisions.

Analytical Technique

Following Mani (2022), farmers' decisions to participate in maize production and the extent of their involvement are modeled within the random utility theory, which assumes that individuals make choices to maximize their expected utility under given constraints. A farmer decides to produce maize if the expected utility derived from maize production exceeds that obtained from alternative (non-maize) livelihood activities.

Let U_i^M and U_i^N represent the utilities associated with maize production and non-maize production, respectively. Farmer i chooses maize farming if:

$$U_i^M > U_i^N \quad (1)$$

Since utility is not directly observable, it is expressed as a function of observed and unobserved components:

$$U_i^M = V_i^M + \varepsilon_i^M \quad (2)$$

$$U_i^N = V_i^N + \varepsilon_i^N \quad (3)$$

Where:

V_i^M and V_i^N are the deterministic (observable) components of utility

ε_i^M and ε_i^N are the stochastic (unobservable) components

The decision to engage in maize production depends on whether the differences in utilities is positive:

$$U_i^M - U_i^N = (V_i^M - V_i^N) + (\varepsilon_i^M - \varepsilon_i^N) > 0 \quad (4)$$

Thus, the probability that a household participates in maize production can be expressed as:

$$P(Y_i = 1) = P\left(U_i^M - U_i^N > 0\right) = P\left(V_i^M - V_i^N > \varepsilon_i^M - \varepsilon_i^N\right) \quad (5)$$

This leads to a binary choice model where Y_i = 1 if the household produced maize as a sole or mixed crop, and Y_i = 0 otherwise (non-maize farming household; did not cultivate maize on any plot). Accordingly, maize production participation was estimated using a probit model.

To jointly capture the decision to participate in maize production and the intensity of participation, the double-hurdle model proposed by Cragg (1971) was employed. The double hurdle model consists of two stages:

First hurdle: Participation decision (Probit model)

The first stage models the binary decision of whether or not a farmer participates in maize production. This was estimated using a probit model, specified as:

$$P(Y_i = 1) = \phi(Z_i'\alpha) \quad (6)$$

Where Y_i denotes a dichotomous variable indicating maize production participation (1 = maize producer, 0 = non-maize producer), Z_i is a vector of explanatory variables influencing the participation decision, α is a vector of parameters to be estimated and ϕ (.) denotes the cumulative distribution function of the standard normal distribution.

Second hurdle: Intensity of Participation (Truncated Regression)

Conditional on a farmer's decision to produce maize (that is, having crossed the first hurdle), the second stage examines the intensity of participation**,** measured as the effective area allocated to maize (hectares), computed as the proportion of each plot cultivated with maize multiplied by the total farm size and aggregated across all plots operated by the household. The intensity equation was estimated using a truncated regression model, specified as:

$$Y_i^* = X_i'\beta + \varepsilon_i, \text{ for } Y_i^* > 0 \quad (7)$$

Where Y_i^* represents the observed level of maize production, X_i is a vector of explanatory variables affecting production intensity, β is a vector of parameters, and ε_i is the error term assumed to be normally distributed. The error terms in the participation and intensity equations are assumed to be independent, allowing the factors influencing the decision to participate in maize production to differ from those determining the level of production

Results and Discussion

Socio-economic Characteristics of Sample Farmers

The results of the descriptive statistics for maize production participants (n = 823) and non-participants (n = 792) are reported in Table 1. Male household heads accounted for over 80% of respondents across both groups, reflecting the dominance of men in smallholder agricultural production in rural Nigeria. Most respondents in the pooled distribution were within the 43–58-year age range, and an average household head age of 53 years. This aligns with Omotayo (2020), who reported a mean age of 54.6 years and observed an ageing farming population. The average household size was approximately seven persons, suggesting potential availability of family labour for maize production, which is consistent with findings by Osabohien *et al*., (2024).

The pooled distribution shows that 58.95% of household heads attained formal education, with a higher prevalence among maize production participants than non-participants. The high prevalence of married household heads (97.28%) observed in this study aligns with findings from Egwue *et al*., (2021), and may be associated with greater household labour availability for maize production. The highest proportion of both maize participants (97.69%) and non-participants (96.84%) were married. Similarly, majority of farmers in both groups cultivated less than one hectare of land, with 74.47% of participants and 82.41% of non-participants falling into this category. This finding corroborates Alawode (2025) who observed that limited landholding among smallholder farmers is often associated with lower levels of agricultural output.

Non-farm income participation is low among the sampled household heads, with over 80.00% reporting zero non-farm income. While the majority of both participants and non-participants lack off-farm earnings, non-participants exhibit a higher mean non-farm income, suggesting greater engagement in alternative livelihood activities. Regarding access to mobile phones, approximately 93.44% of household heads reported owning or having access to a mobile phone, with slightly higher access among maize production participants (94.53%) compared to non-participants (92.30%). This is consistent with Fasakin *et al*. (2025) who reported that mobile phone ownership is associated with improved access to agricultural information and better livelihood outcomes among farming households.

Bank account ownership is moderate among household heads, with higher prevalence among maize production participants, suggesting better financial inclusion. This aligns with Moses *et al*. (2025), who reported that rural households rely on formal banking services to manage financial and production-related risks. Consistent with Wudad *et al*. (2021), who highlighted the role of rural roads in reducing transportation costs and improving input delivery, access to a main road is relatively high among respondents (73.40%).

Production Characteristics of Maize-Producing Household Heads

Table 2 presents selected production characteristics of maize-producing household heads. With respect to land use, the distribution of area allocated to maize indicates that a substantial proportion of participants are relatively maize-oriented. About 58.57% of maize-producing household heads allocated more than 0.50 hectares to maize cultivation, while 23.57% and

17.86% allocated low (≤ 0.25 ha) and medium (0.26–0.50 ha) land areas, respectively. This suggests heterogeneity in maize land-use intensity among participating household heads, reflecting differences in production scale and resource endowment.

Regarding the production system, intercropping dominates maize cultivation among participants, accounting for 72.42% of household heads, compared with 27.58% practicing sole maize production. The predominance of intercropping reflects smallholder production-diversification strategies, land constraints, and the need to diversify output within limited farm size. In terms of total farm size, the majority of maize-producing household heads (60.15%) operate on less than one hectare of land, confirming the smallholder

Table 1: Socio-economic Characteristics of Household Heads

Variables	Pooled			Participants			Non-Participants		
	Freq	Percent	Mean	Freq	Percent	Mean	Freq	Percent	Mean
Sex									
Male	1305	80.80		660	80.19		645	81.44	
Female	310	19.20		163	19.81		147	18.56	
Age									
≤42	457	28.30	52.73	230	27.95	53.13	227	28.66	52.31
43-58	620	38.39		320	38.88		300	37.88	
>59	538	33.31		273	33.17		265	33.46	
Household size									
<4	491	30.40	6.7	252	30.62	6.7	239	30.18	6.7
5-8	700	43.34		361	43.86		339	42.80	
>9	424	26.25		210	25.52		214	27.02	
Education									
Non-formal	663	41.05		310	46.76		353	53.24	
Formal	952	58.95		513	53.89		439	46.11	
Marital status									
Unmarried	44	2.72		19	2.31		25	3.16	
Married	1,571	97.28		804	97.69		767	96.84	
Zone									
North Central	336	20.80		197	23.94		139	17.55	
North East	372	23.03		194	23.57		178	22.47	
North West	358	22.17		136	16.52		222	28.03	
South East	309	19.13		203	24.67		106	13.38	
South South	169	10.46		42	5.10		127	16.04	
South West	71	4.40		51	6.20		20	2.53	
Non-Farm Income (N)									
0	1,300	80.50	29,167.2	666	80.92	22,791.1	634	80.05	35,79
≤ ₦50,000	191	11.83	5	99	12.03	3	92	11.62	2.93
₦50,001- ₦200,000	67	4.15		35	4.25		32	4.04	
₦200,001- ₦500,000	38	2.35		15	1.82		23	2.90	
>₦500,000	19	1.18		8	0.97		11	1.39	
Access Mobile Phone									
Yes	1509	93.44		778	94.53		731	92.30	
No	106	6.56		45	5.47		61	7.70	
Ownership of Bank Account									
Yes	863	50.96		469	56.99		394	49.75	
No	752	49.04		354	43.01		398	50.25	
Main Access Road Present									
Yes	1193	73.40		613	74.48		580	73.23	
No	422	26.60		210	25.52		212	26.77	
Total	**1615**			**823**			**792**		

Source: Authors' Computation from 2023/2024 GHS, freq = frequency, Percent = percentage

nature of maize production in the study area. Household heads with farm size between 1.00 and 2.99 hectares constitute 26.25% of the sample, while only a small fraction operate on land sizes above 3 hectares. This finding corroborates Alawode (2025), who found that most farmers cultivated less than one hectare of land.

Majority of maize farmers (89.06%) produce maize for sale, indicating a strong market orientation among producers, while only 10.94% cultivate maize primarily for non-market purposes. This suggests that maize production in the study area is predominantly driven by income generation rather than subsistence needs.

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Table 2: Production Characteristics of Maize-Producing Household Heads (Participants only)

A. Area Allocated to Maize (ha)		
Category	**Frequency**	**Percent**
Low Allocation (≤ 0.25 ha)	194	23.57
Medium Allocation (0.26 ha - 0.50 ha)	147	17.86
High Allocation (> 0.50 ha)	482	58.57
Total	**823**	**100**
B. Maize Production System		
Category		
Sole Maize Farmers	227	27.58
Intercroppers	596	72.42
Total	**823**	**100**
C. Farm Size(ha)		
Category		
< 1.00 ha	495	60.15
1.00 - 2.99 ha	216	26.25
3.00 - 4.99 ha	55	6.68
≥ 5.00 ha	57	6.93
D. Purpose of Maize Production		
For Sale	733	89.06
Not for Sale	90	10.94
Total	**823**	**100**

Source: Authors' Computation from 2023/2024 GHS

Factors Influencing Maize Production Participation among Rural Farming Households

The results of the Cragg double-hurdle model examining the factors influencing maize production participation are presented in Table 3. The first stage of the model captures farmers' decision to participate in maize production. The model exhibits a strong overall fit, as indicated by a statistically significant Wald chi-square statistic (χ^2 (16) = 7846.87, $p < 0.01$), suggesting that the explanatory variables are jointly significant in explaining participation decision. The Pseudo R^2 value of 0.4019 further indicates a satisfactory model fit. Institutional factors such as ownership of a bank account, access to a main road and geopolitical zones were found to significantly influence farmers' likelihood of participating in maize production.

Among the explanatory variables, ownership of a bank account shows a positive relationship and is statistically significant at $p < 0.05$, indicating that households with bank accounts are more likely to participate in maize production. The marginal effect of 6.3 percent implies that owning a bank account increases the probability of maize production participation by about 6.3 percentage points. These

results are consistent with (Moses *et al*., 2025) who found that financial inclusion enhances farmers' ability to mobilize funds for input purchase and production activities. The coefficient and the marginal effect of access to main road were positive and statistically significant at $p < 0.05$, implying that households with access to a main road are more likely to participate in maize production. Ibrahim and Tolulope (2025) confirmed that households with improved road access are effectively more engaged in production due to easier movement of inputs and produce. Geopolitical location significantly influences farmers' participation decisions. Alawode (2025) identified that geopolitical zones in Nigeria had significant effects on farmers' participation in several ways. Households located in the North East are 9.6 percentage points less likely to participate in maize production than those in North-Central ($p < 0.05$), which may reflect agro-climatic constraints, insecurity, or other structural challenges affecting agricultural activities in the zone. In contrast, households in the North West, South South, and South West exhibit a significantly higher likelihood of participation.

Table 3: Factors Influencing Maize Production Participation among Rural Farming Households

Variables	Coefficient	Standard Error	dy/dx	Z	p-value
Owned a Bank Account	0.16783**	0.06713	0.06262	2.50	0.012
Access to main road	0.19264**	0.08221	0.07187	2.34	0.019
Sex	-0.03160	0.08717	-0.01179	-0.36	0.717
Zone: North East	-0.24666**	0.10521	-0.09607	-2.34	0.019
North West	0.60125***	0.10636	0.23458	-5.65	0.000
South East	0.06732	0.10937	0.025293	0.62	0.538
South South	1.01885***	0.13255	-0.37874	-7.69	0.000
South West	0.30823*	0.17505	0.11028	1.76	0.078
Constant	0.08566	0.10590		0.81	0.419

Observations =1615 Wald chi2(16) =7846.87 Prob>chi2=0.000 Log likelihood =-1347.987 Pseudo R-squared = 0.40, *** = 1% ** =5% and *=10% level of significance

Source: Authors' Computation from 2023/2024 GHS

Factors Influencing Maize Intensity among Rural Farming Households: Table 4 shows that maize production intensity is significantly influenced by labour availability, input use, and land endowment. Age has a negative and weakly significant effect, suggesting that older farmers allocate less land to maize cultivation. Hired labour, herbicide quantity, and household size positively and significantly affect maize production intensity, indicating that both hired and family labour, as well as labour-saving inputs, enable farmers to expand maize cultivation. This aligns with Mani *et al*. (2022), who found a positive impact of labour on production intensity. Land size has a strong positive and highly significant effect, underscoring the importance of land availability in determining the scale of maize production. In contrast, fertilizer use and extension contact do not have significant effects on maize production intensity in the study area.

Table 4: Factors Influencing Maize Production Intensity among Rural Farming Households

Variables	Coefficient	Standard Error	Z	p-value
Age	-0.000318*	0.00173	-1,86	0.063
Age squared	0.000048	0.000097	0.50	0.620
Hired labour (mandays)	0.0031161***	0.00099	3.14	0.002
NPK (kg)	0.000318	0.00020	1.58	0.114
Herbicide (kg)	0.00808**	0.003195	2.53	0.011
Household size	0.015530**	0.00619	2.51	0.012
Extension contact	0.046678	0.05213	0.90	0.371
Land size (ha)	0.96552***	0.00099	84.09	0.000
Constant	-0.55504	0.07093	-7.82	0.000

Source: Authors' Computation from 2023/2024 GHS
*** = 1% ** =5% and *=10% level of significance

Conclusion

Maize production is characterized by predominantly intercropping practices alongside substantial land allocation to maize, underscoring the intensity of farmers' engagement in maize cultivation. More so, majority of maize farmers produce maize for sale, indicating a strong market orientation. While participation is driven mainly by financial access (owning a bank account), access to main road, and regional location, production intensity among participants is largely influenced by farm size and herbicide quantity, hired labour, household size and farm size. The significant and negative link between age and production intensity suggests that older farmers allocate less land to maize cultivation. Sex has a negative but statistically insignificant effect on maize production intensity, suggesting that gender does not play a decisive role in determining production outcomes among participating households. Overall, the study show that maize production participation and intensity are governed by different decision processes.

Recommendation

The findings suggest a need to improve the quality and effectiveness of extension services, as weak impacts may stem from limited farmer coverage, inadequate content, or poor delivery mechanisms. Since most farmers practice intercropping, policies should prioritize the development and dissemination of improved maize-based intercropping technologies that enhance productivity without intensifying resource competition. Support for maize farmers should emphasize better market access and enhanced productivity, as the majority produce maize primarily for sale. Additionally, the strong influence of regional location underscores the importance of tailoring maize production policies to local agro-ecological and infrastructural conditions, with targeted support for regions exhibiting lower participation rates.

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