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Maize Productivity Transitions among Farmers in Nigeria

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Abstract

The study analyzes maize farming productivity state transitions in Nigeria using data from the 2015 and 2018 General Household Survey-Panel to identify the socioeconomic and institutional factors influencing productivity development over time. Nigeria's national food security and rural livelihoods depend on maize, an essential staple crop. Maize farmers lag behind local competitors because their production system operations are insufficient. The study used Markov Chain analysis and multinomial logistic regression to analyze productivity category movement patterns and their corresponding determinants. Among the farmers from 2015, only 71.4 percent maintained productive status in 2018, while 28.6 percent left the category. A total of 79.2% of non-productive farmers transformed into productive groups between 2015 and 2018 based on Markov Chain analysis. In the long run, it is predicted that the majority of the farmers, 65%, will remain productive. The regression analysis confirmed that age, together with household size and sex, demonstrated statistical importance in the determination of productivity transitions. Older farmers and large households experienced increased chances of productive continuation and initiation, but men showed a reduced likelihood of exiting productivity. Despite many farmers transitioning into productive zones, limitations exist because of restricted credit access, minimal contact with extension services, and small production areas. Productivity, sustainability, and maize farmer resilience require specific interventions, including better extension programs, affordable credit, and cooperative membership enhancement. The research outcome makes valuable contributions to governmental authorities who aim to improve agricultural program results while promoting sustainable maize development in Nigeria.

Key Words: *Productivity Transition, Maize, Nigeria, General Household Survey, Markov Chain*

Introduction

Maize is the most significant cereal crop in sub-Saharan Africa, which is farmed by over 50% of the continent's population (FAO, 2006). It is the principal cereal crop in Nigeria and the principal cereal crop in West Africa (Ayedun, 2018). Maize (Zea mays), a staple crop, holds a significant position in Nigeria's agricultural economy, contributing to food security and livelihood for millions (Wossen *et al., 2023).* As Africa's second-largest maize producer, Nigeria recorded an estimated 11 million metric tons of production in 2019, harvested from over 6.8 million hectares (Wossen *et al*., 2023). Despite its expansive cultivation, productivity levels have remained stagnant at approximately 1.7 tons per hectare, markedly lower than those of other leading African producers such as South Africa and Ethiopia, with 4.9 and 4.2 tons per hectare yields, respectively (PwC, 2021).

The productivity transition among Nigerian maize farmers is shaped by a complex interplay of factors, including technology adoption, resource allocation, and socioeconomic dynamics (Ibitola *et al.,* 2019). Recent studies highlight the critical role of improved maize varieties in bridging the productivity gap. For instance, adopting these varieties has been shown to enhance yields by up to 38.7%, driven primarily by technological advancements rather than improvements in managerial efficiency (Olasehinde *et al*., 2023). However, the persistent underutilization of efficient farming practices underscores the need for targeted interventions.

According to Mekonnen (2021), there has been extensive nationwide promotion toward advancing, propagating, and accepting enhanced crop varieties and fertilizer technology; still, the nation's agriculture industry is characterized by low productivity. Interventions seem important in raising the output level in a particular setting, but these increases are prone to inefficiency, particularly when the available technology is not used effectively. These issues are further compounded by climate variability and declining soil fertility, which disproportionately affect smallholder farmers who constitute the majority of maize producers in Nigeria (Ogbodo *et al.,* 2018). Addressing these challenges requires a multifaceted approach that includes improving access to agricultural inputs, promoting sustainable farming practices, and enhancing market linkages.

This study explores the dynamics of productivity transitions among maize farmers in Nigeria, examining the influence of socio-economic factors. Understanding these transitions is critical for formulating policies that improve maize yields, enhance the livelihoods of smallholder farmers, and contribute to national food security.

Materials and Methods

Study Area

The study was conducted in Nigeria, West Africa, at Latitude 9° 04' 39.90" N and Longitude 8° 40'. As of April 2025, the population of Nigeria is approximately 237 million 2025. 38.84" E, Africa's most populous nation and the sixth most populous country globally (Worldometer, 2025). The Federal Capital Territory, Abuja, and 36 states comprise the federal constitutional republic, the Federal Republic of Nigeria. The West African nation of Nigeria is bordered on land by the Republic of Benin to the west, by Chad and Cameron to the east, by Niger to the north, and by the Atlantic Ocean to the south. Nigeria is a 923,768 km³ nation in Africa. Nigeria has just two seasons, just like the rest of West Africa and other tropical regions. There are two of these: the rainy and the dry seasons. While the rainy season is greatly impacted by an air mass originating from the South Atlantic Ocean, popularly known as the South Western wind, the dry season is accompanied by an air mass packed with dust from the Sahara Desert, commonly known as Harmattan (Jeník & Hall, 1966). A brief and longer dry season comes between and after each peak in the two-fold rainfall maximum that the southern part of Nigeria experiences.

Data Source

The data for this study were obtained from the 2015 and 2018 Nigerian General Household Surveys (GHS). The GHS-Panel component in Nigeria is part of a regional initiative to improve agricultural statistics in Sub-Saharan Africa. The data was collected by the National Bureau of Statistics (NBS) in collaboration with the Federal Ministry of Agriculture and Rural Development (FMA&RD), National Food Reserve Agency (NFRA), World Bank (WB), and Bill and Melinda Gates Foundation (BMGF). The GHS-Panel aims to develop a leading paradigm for agricultural data collection, foster inter-institutional collaboration, and analyse welfare indicators and socioeconomic features. The 5,000-household GHS-Panel poll represents all households and geopolitical zones (urban and rural). A subset of the GHS sample homes is the GHS panel. The General Household Survey used a multi-stage stratified sample design. Nigeria's GHS sample includes 60 Enumeration Areas (EAs) or Primary Sampling Units (PSUs) from its 37 states, totalling 2220 EAs nationally. A survey of 456 respondents was used across all states and regions. Data on yield and household socioeconomic factors, including size, age, gender, marital status, education level, farm size, access to credit, and extension services, were gathered.

Analytical Technique

Markov Chain

The Markov chain model was used to determine the level of productivity transition among the maize farmers. The Markov model is converted into probability values of entering and exiting productivity by dividing each item by the corresponding row total to give the transition probability below.

$X_{11}\ X_{21}\ (X_{12}\ X_{22})$

Also, the vector of initial probability P (o) was obtained by dividing each column total by the total. Thereafter, we tried to see the proportion of households that will be in each category in the subsequent periods by using

$P(k) = P(o)\ Pk$

Where k is the period in seasons.

Long-term equilibrium (when the proportion of households entering productivity equals the proportion exiting it) was obtained by using

$eP=e$

$(e_1, e_2)\ (X_{11}\ X_{12}, X_{21}\ X_{22}) = (e_1, e_2)$

The solution to the above equation produced e_1 and $e_{2,}$ the proportion of households that will be productive and at equilibrium in the long run.

Where e_1 = probability of households that will be productive at equilibrium

e_2 = probability of households that will be non-productive at equilibrium

Multinomial Logistics Regression

The multinomial logistics regression model was used to estimate the determinant of productivity transition among the maize farmers. Multinomial logistic regression was used to model nominal outcome variables, in which the log odds of the outcomes are modeled as a linear combination of the predictor variables. A multinomial logistic regression was performed to create a model of the relationship between the predictor variables and membership in the other groups. Multinomial logistic regression is the extension for the (binary) logistic regression when the categorical dependent outcome has more than two levels (Anderson & Rutkowski, 2008).

Following Adepoju (2012) and Ayantoye (2011), the multinomial logit regression model can be expressed explicitly as

$$Y_0 = \alpha_0 + \beta_{10}X_1 + \beta_{20}X_2 + \ldots\ldots\ldots + \beta_{n0}X_n + \mathcal{E}_{i0} \ldots\ldots\ldots (1)$$

$$Y_1 = \alpha_1 + \beta_{11}X_1 + \beta_{21}X_2 + \ldots\ldots\ldots + \beta_{n1}X_n + \mathcal{E}_{i0} \ldots\ldots\ldots (2)$$

$$Y_2 = \alpha_2 + \beta_{12}X_1 + \beta_{22}X_2 + \ldots\ldots\ldots + \beta_n 2_{Xn} + \mathcal{E}_{i0} \ldots\ldots\ldots (3)$$

$$Y_3 = \alpha_3 + \beta_{13}X_1 + \beta_{23}X_2 + \ldots\ldots\ldots + \beta_n 3_{Xn} + \mathcal{E}_{i0} \ldots\ldots\ldots (4)$$

Y_0 = those who entered productivity (which is the reference case)

Y_1 = those who are consistently productive

Y_2 = those who exited productivity

Y_3 = those who are always non-productive
$X_1 \ldots X_n$ represent the vector of the explanatory variables
$\beta_1 \ldots \beta_n$ represent the parameter coefficients.
ε_i = represents the independently distributed error terms
$\alpha_0 - \alpha_3$ = shows the intercept or constant terms.

Results and Discussion

This section discusses the socio-economic characteristics of the maize farmers. These include Sex, Age, Marital status, Education level, Household size, Credit access, Membership in cooperatives, etc. As shown in Table 1, 79.6% of the respondents were male, and 20.4% were female. The majority, approximately 64%, had only primary education. In comparison, about 76% of the respondents were married. In comparison, the majority of about 98% have no access to extension contact, while the majority of about 90% among the respondents have no access to credit. In contrast, the mean age of the respondents was 53 years, the average farm size cultivated for maize was 1.17 hectares, and the average household size was nine persons.

Table 1: Demographic characteristics of the respondents in the study area

Demographic variables	Frequency	Percentage	Mean
Sex			
Male	363	79.61	
Female	93	20.39	
Level of Education			
No education	29	6.36	
Primary	293	64.25	
Secondary	116	25.44	
Tertiary	18	3.95	
Marital status			
Unmarried	109	23.90	
Married	347	76.10	
Access to extension service			
Yes	11	2.41	
No	445	97.59	
Access to credit			
Yes	44	9.65	
No	412	90.35	
Age			53 years
<21	5	1.10	
21-30	13	2.85	
31-40	71	15.57	
41-50	111	24.34	
51-60	117	25.66	
>60	139	30.48	
Farm size			1.17 hectares
1	267	58.55	
1-5	178	39.04	
>5	11	2.41	
Household size			9 persons
<6	102	22.37	
6-10	236	51.75	
>10	118	25.88	
Total	456	100.00	

Level of Productivity Transition among Maize Farmers

Table 2 shows the results of the transition matrix and their probabilities. The results are in line with the work of Baulch and McCulloch (2002). The results revealed that 71.4% of farmers who were productive in 2015 remained productive in 2018, while 28.6% of those who were productive in 2015 transitioned to non-productive in 2018. Also, 79.2% of non-productive people in 2015 transitioned to being productive in 2018, while 20.8% in 2015 remained non-productive in 2018.

Furthermore, the result showed that in the short run, the probability that a farmer will be productive is 77.1%, while the probability that a farmer will be non-productive is 22.8%.

In Equilibrium, i.e, the long run, the probability that a maize farmer will be productive in the long run is 65.0%, while the probability that the maize farmer will be non-productive in the long run is 35.0%. This shows that most maize farmers will be productive in the long run.

Table 2: Level of Productivity Transition among Maize Farmers

2015	2018		Total
	Productive	Non-Productive	
Productive	85 (71.4)	34(28.6)	119 (26.1)
Non-Productive	267 (79.2)	70 (20.8)	337 (73.9)
Total	352 (77.1)	104 (22.8)	456 (100)

Productivity Transitions Across Demographic Characteristics of the Maize Farmer

The section discusses productivity transitions among maize farmers based on demographic characteristics such as sex, age, education, marital status, and farm size. Key findings from Table 3 show that 81% of consistently productive farmers are male; 56% of those who exited productivity are female; 85% of new productive farmers are male; 73% of non-productive farmers are male. The majority of all the groups (always productive, exited, entered, non-productive) have primary education, ranging from 62% to 79%. 42% of consistently productive farmers are aged 51-60; 47% of those who exited productivity are aged 51-60 or above 60. In terms of marital status, 78% of consistently productive farmers are married; 56% of those who exited productivity are unmarried; 81% of new productive farmers are married; 69% of non-productive farmers are married Likewise, all groups have less than 1 hectare of land, ranging from 54% to 79%. Most farmers in all groups have 6-10 household members access. 97% of always productive and exited farmers lack access to extension agents, while 99% of those who entered productivity farmers lack access; 96% of non-productive farmers lack access. The majority of the farmers do not have access to credit, and this becomes evident in the groups as 95% of always productive farmers lack access; 82% of exited farmers lack access; and 90% of both new productive and non-productive farmers lack access.

Determinants of Productivity Transition among Maize Farmers

The multinomial logistics regression model was used to estimate the determinant of productivity transition among the maize farmers. As shown in the result, the P level of 0.00 (P<0.005) indicates that there is goodness of fit in the model. A unit increase in age will lead to a 0.1189 increase in being always productive compared to those entering productivity. It is significant at 10%. This indicates that an increase in age will contribute to an increase in 2015 and 2018 relative to entering productivity. A unit increase in household size will lead to a 0.0594 increase in being always productive compared to those entering productivity. It is significant at 5%. This means that an increase in household size will contribute to an increase in being productive in the years 2015 and 2018 relative to entering productivity. Tura *et al. (2010) agree* that household size significantly influences continued productivity among maize farmers. A unit increase in age will lead to a 0.3047 increase in exiting productivity compared to those entering productivity. It is significant at 10%. This indicates that an increase in age will contribute to increased existing productivity from 2015 to 2018 relative to entering productivity. A unit increase in household size will lead to a 0.0808 increase in exiting productivity compared to those entering productivity. It is significant at 5%. This means that an increase in household size will contribute to an increase in exiting productivity from 2015 to 2018 relative to entering productivity. Idris *et al.* (2015) *indicate that household size is a factor affecting the efficiency and productivity of maize farmers*. Being a male farmer will lead to a 2.2269 decrease in exiting productivity compared to being a female farmer relative to those entering productivity. It is significant at 1%. This means that being a male farmer will decrease exiting productivity compared to being a female farmer from 2015 to 2018 relative to entering productivity.

Being a male farmer will lead to a 0.7137 decrease in non-productivity compared to being a female farmer relative to those entering productivity. This is significant at 5%. This means that being a male farmer will decrease non-productivity compared to being a female farmer in 2015 and 2018 relative to entering productivity.

Table 3: Distribution of Productivity Transitions across Socioeconomic characteristics

Variables	Always Productive Freq (%)	Exit Productivity Freq (%)	Entered Productivity Freq (%)	Always Non-Productive Freq (%)	Total Freq (%)
Sex					
Male	69 (81.2)	15 (44.1)	228 (85.4)	51 (72.9)	363 (79.61)
Female	16 (18.8)	19 (55.9)	39 (14.7)	19 (27.1)	93 (20.4)
Educational level					
No formal	10 (11.8)	0 (0)	18 (6.7)	1 (1.4)	29 (6.36)
Primary	53 (62.3)	27 (79.4)	161 (60.3)	52 (74.3)	293 (64.2)
Secondary	22 (25.9)	7 (20.6)	73 (27.3)	14 (20.0)	116 (25.4)
Tertiary	0 (0)	0 (0)	15 (5.6)	3 (4.3)	18 (3.9)
Age					
<21	0(0)	0 (0)	5(1.9)	0(0)	5(1.1)
21-30	3(3.5)	0(0)	8(3.0)	2(2.9)	13(2.8)
31-40	14(16.5)	2(5.9)	48(18.0)	7(10.0)	71(15.6)
41-50	15(17.7)	0(0)	76(28.5)	20(28.6)	111(24.3)
51-60	36(42.3)	16(47.1)	59(22.1)	6(8.6)	117(25.7)
>60	17(20.0)	16(47.1)	71(26.6)	35(50.0)	139(30.5)
Marital status					
Unmarried	18(21.2)	19(55.9)	50(18.7)	22(31.4)	109(23.9)
Married	67(78.8)	15(44.1)	217(81.3)	48(68.6)	347(76.1)
Farm size					
<1	50(58.8)	27(79.4)	145(54.3)	45(64.3)	267(58.5)
1-5	34(40.0)	5(14.7)	117(43.8)	22(31.4)	178(39.0)
>5	1(1.2)	2(5.9)	5(1.9)	3(4.3)	11(2.4)
Household size					
<6	12(14.1)	9(26.5)	58(21.7)	23(32.9)	102(22.4)
6-10	49(57.6)	20(58.8)	137(51.3)	30(42.9)	236(51.7)
>10	24(28.2)	5(14.7)	72(27)	17(24.3)	118(25.9)
Extension contact					
Yes	3(3.5)	1(2.9)	4(1.5)	3(4.3)	11(2.4)
No	82(96.5)	33(97.1)	263(98.5)	67(95.7)	445(97.6)
Access to credit					
Yes	4(4.7)	6(17.6)	27(10.1)	7(10.0)	44(9.6)
No	81(95.3)	28(82.3)	240(89.9)	63(90.0)	412(90.4)
Total	**85 (100)**	**34 (100)**	**267 (100)**	**70 (100)**	**456 (100)**

Table 4: Determinants of Productivity Transition among Maize Farmers

Productivity Transition	Always Productive		Exited Productivity		Always Non-Productive	
	Coefficient (Standard Error)	P>z	Coefficient (Standard Error)	P>z	Coefficient (Standard Error)	P>z
Age	0.12(0.069)***	0.083	0.305(0.158)***	0.054	-0.035 (0.058)	0.541
Household Size	0.059 (0.028)***	0.035	0.081 (0.035)**	0.022	0.001 (0.033)	0.964
Farm size	-0.124 (0.110)	0.262	0.110 (0.173)	0.526	0.098 (0.102)	0.336
Sex (Male)	-0.515(0.362)	0.155	-2.227 (0.476)*	0.000	-0.714 (0.359)	0.047
Cooperative (Yes)	-0.002 (0.647)	0.997	0.874 (0.659)	0.185	0.324 (0.572)	0.571
Credit (Yes)	-0.824 (0.559)	0.140	0.633 (0.557)	0.256	-0.017 (0.4664)	0.971
Log Likelihood = 468.52835 Number of obs. = 456 LR chi^2 (21) = 73.23 Prob > chi^2 = 0.0000 Pseudo R^2 = 0.0725						

*, **, *** signifies 1%, 5%, 10%, respectively.

Conclusion

This study examined the productivity transitions among maize farmers in Nigeria, focusing on factors influencing their movement between productivity categories over time. The findings revealed that while a significant proportion of farmers (71.4%) remained consistently productive, 28.6% transitioned out of productivity due to limited access to credit, small farm sizes, and lack of support from extension services. Additionally, farmers who entered productivity between 2015 and 2018 showcased the positive impact of socioeconomic variables, including household size and education levels. However, the persistence of non-productivity among a minority of farmers highlights structural and operational challenges within the maize farming sector.

Recommendations

Based on the findings, policymakers should strengthen rural financial institutions to provide affordable credit facilities tailored to smallholder farmers. This intervention would mitigate financial constraints and enable farmers to invest in productivity-enhancing inputs and technologies. Expanding the network of extension agents is critical to disseminating knowledge about improved farming practices and technologies. This includes training programs that emphasize sustainable farming and resource management strategies. The study also recommended encouraging the formation of cooperatives, which can facilitate resource pooling, reduce operational costs, and enhance access to markets and financial resources. Such collaborative frameworks have been proven to improve productivity among smallholder farmers. The government and private sector must also invest in rural infrastructure, including roads and storage facilities, to reduce post-harvest losses and improve market access. By implementing these recommendations, productivity transitions among maize farmers in Nigeria can be significantly improved, fostering a more resilient and sustainable agricultural sector.

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