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Factors influencing smallholder adoption of organic agriculture in Southeast geopolitical region of Nigeria

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Introduction: Organic Agriculture is considered one of the promising sustainable agricultural systems that can promote green economy measures, especially in developing countries where smallholder agriculture forms the backbone of the economy. With increasing awareness of the environmental and health benefits of organic foods, there has been an increasing number of studies assessing the demand side (determinants of consumers' demand for organic products) within the global South. However, there is a dearth of research information on the supply side (e.g., factors influencing smallholder farmers' willingness to engage in organic agriculture). To scale up organic agriculture among smallholder farmers, there is a need to explore and understand the factors influencing its adoption.

Methods: Using survey data from rural Nigeria, this paper applied Cragg's double-hurdle model to assess the factors influencing smallholder farmers' adoption of organic farming in the Southeast geopolitical region of Nigeria.

Results: The result showed that information about organic farming plays a major role in motivating farmers to adopt organic farming. Farmers that know what organic farming entails were found to be 1.31 percent more likely to adopt organic farming and to dedicate 1.23 percent more of their land to organic farming than the farmers that are less aware of organic farming. Similarly, an organized organic marketing structure and a premium on organic products were found to statistically improve the adoption of organic farming. The proportion of land dedicated to organic farming was found to be 2.15 percent more for farmers that received a premium for their organic produce than their counterparts that do not receive a premium for their produce.

Discussion: The findings demonstrated policy actions aimed at certification among smallholder farmers employing organic farming methods can facilitate system-wise organic farming in rural areas. However, the nature of such certification that will not jeopardize the agency of the farmers requires further investigation.

KEYWORDS

Southeast Nigeria, organic agriculture, adoption, smallholders agriculture, Cragg's double-hurdle model

1. Introduction

As an application of a sustainable production system (Schreer and Padmanabhan, 2020) organic farming plays a key role in realizing the different sustainable agricultural goals. This means that organic farming does not only provide sufficient food for practitioners but also ensures environmental and natural resource benefits, by limiting the use of non-renewable resources and external inputs, thereby ensuring the sustainability of the livelihoods of farmers and their communities over time. Different scientific disciplines have increasingly strived to configure ways through which the adoption of organic practices will not only help in reducing the impact of climate change but also help to reverse the negative climate change effects that we have experienced over the past decades (Alexander-Bloch et al., 2016; Zanoli et al., 2019; Swenson and Conbere, 2021). As stakeholders and policymakers begin to raise concerns about the depletion of finite resources and the related consequences such as climate change, land degradation, biodiversity loss, human health issues, and more, continued unsustainable farming systems would no longer be an option. However, mainstream agricultural thinking should be re-focused on sustainable intensification driven by science and indigenous knowledge that is based on natural processes.

In this study, we adopted the definition of organic agriculture as stipulated at the 2008 International Federation of Organic Agriculture Movements (IFOAM) general assembly where organic agriculture was defined as "a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity, and cycles adapted to local conditions, rather than the use of inputs with adverse effects. It combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved" (IFOAM 2023). Organic agriculture has emerged as a holistic and interdisciplinary scientific approach that tends to combine the economics of productivity, ecology, agronomy, sociology, and politics of food at different levels and scales (HLPE, 2019). Organic farming, also known as ecological agriculture or biological farming, is a farming system that uses fertilizers of organic origin such as compost, green manure, and bone meal, and emphasizes techniques such as crop rotation and mixed cropping (Durán-Lara et al., 2020). Organic farming goes one step further and encompasses the entire production system. It focuses on soil health, renewable resources, animal welfare, and environmentally friendly practices. Organic farming and ecological agriculture, although they are two different terms, they portray the same concept (Ume et al., 2022). Although organic farming pertains to the specific methods used on a farm, organic agriculture covers the complete production chain from the farm to the consumer, which includes processing and distribution. Organic farming may be useful for biodiversity and environmental safety at the neighborhood level (Ajao et al., 2010). However, because natural farming has decreased yields compared to standard farming (Knapp and Heijden 2018), extra agricultural land is wanted in some other places in the world, which means that arable land must be transformed into agricultural land. We conceptualize organic farming as the farming method whereby farmers dedicate their land to crop production devoid of the use of chemicals such as inorganic fertilizers, pesticides, or herbicides. Broadly, we distinguish different areas where farmers could integrate organic farming techniques and their relevance based on Ume (2023).

i. *Crop diversity*: The practice of organic farming promotes the cultivation of a variety of crops. The field of Agroecology has demonstrated the advantages of polyculture (cultivating multiple crops in the same area), a technique commonly utilized in organic farming. Planting diverse vegetable crops promotes a broader spectrum of advantageous insects, soil microorganisms, and other elements that contribute to the general well-being of the farm. Crop diversity is crucial in maintaining a flourishing environment and safeguarding species from extinction.
ii. *Soil management*: organic agriculture places greater emphasis on the natural breakdown of organic matter than typical conventional farming. It utilizes methods like composting and green manure to replenish nutrients that have been depleted from the soil by previous crops. This biological process, facilitated by microorganisms such as earthworms and mycorrhiza, releases nutrients that are available to plants throughout the growing season. Farmers employ diverse techniques to enhance soil fertility, like crop rotation, cover cropping, compost application, and reduced tillage. By minimizing fuel-intensive tillage, the loss of soil organic matter to the atmosphere is curtailed. This also has the added benefit of sequestering carbon, which mitigates greenhouse gases and helps to counteract climate change. Reducing tillage may also bolster soil structure and lessen the potential for soil erosion.
iii. *Weed management*: Organic farmers use a combination of cultural, biological, mechanical, physical, and chemical methods to manage weeds without using synthetic herbicides. Organic farming requires the rotation of crops, which means that the same crop cannot be grown in the same location without an intervening crop that is different. Organic crop rotations frequently involve using weed-suppressing cover crops and crops with different life cycles to discourage weeds that are associated with a particular crop. Research is ongoing to discover organic techniques that promote the growth of natural microorganisms that can inhibit the growth or germination of common weeds. Additional cultural practices, such as selecting competitive crop varieties, planting at high densities, using narrow row spacing, and planting late into warm soil to encourage rapid crop germination, are used to enhance crop competitiveness and decrease weed pressure.

In Africa, due to high poverty levels, population expansion, and the growing demand to safeguard the environment, the need for achieving food and nutritional security, there is a need for a rapid shift from conventional agricultural practices that employ external inputs, which have adverse effects on the soil and people's health (Ume 2023). Efforts should be focused on increasing a more sustainable food system that simultaneously supports environmental sustainability and food productivity while promoting rural livelihoods. Organic farming has emerged as a sustainable practice that can improve the above challenges, as it has been proven to be efficient, productive, and resilient (Iyagba and Ovai, 2015; Farrelly, 2016; FAO, 2019). Several networks and organizations are working towards establishing organic farming as a way of meeting the food and nutrition needs of the rural population in Africa (Gliessman, 2016). Gliessman (2016) described these sets of networks of individuals and organizations broadly as a social movement that strives to make the agricultural food system not only more resource-efficient but also people-focused. However, for such movements to gain grounds in scaling up organic farming, there is a need to understand what factors drive and influence the adoption of organic farming in the region.

In Nigeria, a number of studies on sustainable agriculture that have identified immediate determinants and drivers of food security (see FAO, 2018; Nyoni and Bonga, 2018; Opata and Ezeibe, 2018) did so without considering the underlying structures such as the socioeconomic and institutional factors that undermine sustainability in the national food systems. Addressing these underlying sustainability issues rather than the superficial drivers is key to building resilience in national food systems. As stated by Gladek et al. (2016) these underlying causes vary from place to place and are still argued, thus, there is a need for further empirical research to clear uncertainties and establish a coherent scholarship in this area of drivers of sustainable farming transition. Studies in this direction are, therefore, required to establish context-specific evidence on the necessary structural transformations within the national food system capable of moving the national food system to a more sustainable and resilient state. With increasing awareness of the health benefits of organic foods (Guilabert and Wood 2012), there has been an increasing demand for organic products by consumers within the global South (Schreer and Padmanabhan, 2020). However, the expansion in the adoption of organic farming has been at a slow pace. To scale up organic farming among smallholder farmers, there is a need to understand the factors influencing the adoption of organic farming.

2. Framing the study

To scale up organic farming among farmers, there is a need to understand the potential drivers and motivations for the adoption of organic farming among farmers. This is often regarded as the demand-side driver [Food and Agriculture Organization of the United Nations (FAO) 2014]. Our earlier study investigated the potential of organic farming in improving food and nutrition security among organic farmers (Ume 2023). In the study, we sought to understand if improved market access among the same population of smallholder organic farmers used in this study will mediate the relationship between the adoption of organic farming and its food security. The result showed that smallholder organic farmers who are more oriented towards the market (i.e., they sell a greater percentage of the total organic produce) have better food security and nutrition (see Ume, 2023). However, apart from market orientation mediating the link between organic farming and food security, there is a need to understand what factors that motivate farmers to adopt organic farming and also the extent of adoption. This is important because it is common among the population of the study area of organic farmers to allocate only a small portion of their farms for organic crop cultivation (Ume, 2023). Various important economic and socio-political factors could also motivate or hinder farmers not only to adopt organic farming but to make a substantial or even a total switch from conventional farming to organic farming. Our previous analysis was silent in this regard. While we were able to show how improving market access will improve the food and nutrition of organic farming, there is still the need for a more comprehensive understanding of the various factors that can motivate smallholder farmers to adopt organic farming. This is important as it will better our understanding of how to frame an approach that will encourage the transition to more sustainable agriculture.

Studies such as Enete and Amusa (2010), Onyeneke et al. (2018), and Ume (2018) have provided substantial evidence of the need for more sustainable agriculture if Nigeria is to meet up with her Nationally Intended Determined Contribution (INDC) to reduce emissions from the agricultural sector. Critically inadequate, however, are the drivers of sustainable agriculture and food system (of which organic farming is paramount) in Nigeria, which is based on comprehensive and robust field data. This gap is what this research intends to fill. Additionally, there is a paucity of knowledge on any published study documenting the state of knowledge and practice of organic farming by farmers in Nigeria, which is based on field data that is detailed and consistent. Oyedele et al. (2018) employed a qualitative method to understand the opinion of small-scale farmers employing organic farming methods on the benefit of organic farming towards their food security status. The authors reported that the small-scale farmers (who were not organic farming practitioners) were of the opinion that organic farming will not benefit them. Okon et al. (2010) sufficiently investigated the factors influencing the adoption of organic vegetable farming among farm households in the South–South region of Nigeria. However, the study aggregated all the farmers at different levels of adoption. For instance, farmers who use organic fertilizers but employed organic methods of pest control were grouped together with farmers who used 100% organic production systems in all aspects of their farming practice. This present study not only provides further insight into the drivers of organic farming adoption but also employed a large sample of disaggregated data of smallholder farmers at different stages of adoption.

With the emergence of different agroecology groups in Southeast Nigeria (Emeana et al., 2018), farmers have started adopting organic farming at different levels. Most of the farmers who adopt organic farming only dedicate a little portion of their land to organic farming and some will use this organic portion for feeding their households while they sell conventional produce to the market. As a justification, conducting this study is necessary to articulate needed improvements in practice and policies that need to be made to encourage more adoption and commercialization and adoption of organic farming practices, how these improvements are to be done, and finally show how results can be measured. In essence, this study will provide guidelines for the federal, state, and local governments to design informed policies needed to ensure organic farming transition, as well as provide the basis for performance monitoring. The broad objective of this study was to investigate the status of organic farming in Southeast Nigeria. To achieve the above objective, this research provided answers to the following questions: what are the institutional and socioeconomic factors that influence influencing smallholder farmers' adoption of organic farming in the Southeast geopolitical region of Southeast Nigeria? By applying a relevant sustainable food system framework, areas of higher-leverage interventions can be identified. The overarching aim is to derive evidence and lessons for policymakers, eliciting informed actions and procedures on how to fashion organic farming strategies and transformational food systems in the country.

According to Wezel and Soldat (2009), research on organic agriculture mostly concentrates on the interaction between crops and pests or crops and weeds. The impact pesticides have on the natural flora and fauna and how natural processes can be beneficial. In animal production, the interactions between animals and pastures are analyzed. However, studies on the plot and farm scale do not consider the social science components. However, in the recent past, with increased intensification, occasioned by the need to feed the ever-increasing population, the social and behavioral science that looks at the political, institutional, and human disposition towards acceptance and application of organic farming need to be better understood (Ume et al., 2021). As indicated by Giller et al. (1997), with this increasing quest for sustainable intensification, peasant farmers are incapacitated in terms of the availability of a market for organic produce.

3. Methodology

3.1. Study area and data

The study area was the Southeastern geopolitical region of Nigeria (Figure 1). Southeastern geopolitical region of Nigeria is one of the six geopolitical zones in the country. It comprises five states – Imo, Enugu, Ebonyi, Anambra, and Abia (Onyekuru et al., 2020). The region is characterized by a tropical monsoon climate (Onyekuru et al., 2020). The region lies between latitude 23° 27′ north to 23° 27′ South, with an average rainfall of between 2,000 and 3,000 mm (118.1 in) per year (Onyekuru et al., 2020). The major language in the region is Igbo language. With about 22 million people (National Population Commission, 2022), the people in the rural area are mostly agrarian in nature as they have farming as their major occupation. This study used data collected between September 2020 and July 2021 by the Center for Agroecology, located in Southeast Nigeria. The center was instituted in 2017 by a group of researchers from the University of Nigeria. The data consisted of a sample of 1,251 rural farmers. The data is open access on Figshare data repository. The data used for this study is the same data used in a previous study investigating the mediating effect of access to market on the relationship between adoption of organic farming and food security (see Ume, 2023). The population in this study is the same as the population investigated in our previous study. The data were collected based on a multistage sampling technique. In the first stage, the five states (Abia, Enugu, Anambra, Ebonyi, and Imo state) in Southeast Nigeria (Figure 1) were purposefully selected. This region was selected because the agroecology movement in Nigeria started in the area and there is a greater chance of sampling more farmers employing organic farming methods in this region. Next, all the local government areas (LGAs) in the respective states were selected (Abia state = 17 LGAs; Imo state = 27 LGAs; Ebonyi state = 13 LGAs; Anambra state = 21 LGAs; and, Enugu state = 17 LGAs), making it a total of 95 local government areas covered. Finally, the survey sampled 15 farmers from each of the 95 LGAs giving a total of 1,425 farmers. However, after cleaning, usable data from 1,251 farmers were utilised for analysis and this comprised of 415 farmers who practice varying levels of organic farming and 838 conventional farmers.

The unit of investigation in the survey was only smallholder farmers. For the survey, the definition of a smallholder farm follows from FAO (2020). In this regard, a farm household is a smallholder when it manages a land area of less than 5 hectares. To capture only smallholder farm households, the survey asked a control question on the land size of the farmer at the beginning to determine the eligibility of participating farmers.

The survey elicited data on individual and household demographic characteristics, asset ownership, access to services such as extension, markets, and credit, off-farm income-generating activities, networking, and social capital. A second part of the questionnaire elicited information on the market orientation of the farmers and the level of adoption of organic farming. Organic farming was measured using the dichotomous dummy of 0 and 1, where 1 represents farmers who fully or partly adopts organic farming, and 0 otherwise (Table 1).

3.2. Econometric approach

The econometric procedure involves two stages. First is the decision to adopt or not to adopt organic farming which involves a discrete choice

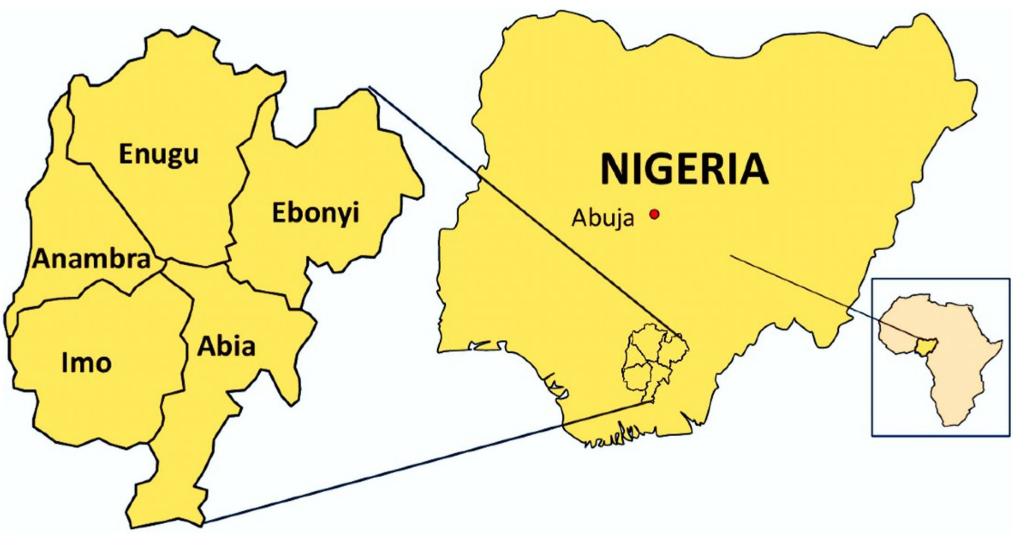

FIGURE 1
Map of Southeast Nigeria showing the research areas (Ume 2023).

TABLE 1 Definition and descriptive statistics of exogenous, outcomes and control variables.

Variables	Description	Mean	Std dev.
Outcome variables			
Organic farming	Farmer adopting organic farming (1 = organic; 0 = Other)	0.33	–
Intensity of organic farming	Proportion of land dedicated for organic farming	0.67	0.11
Variables of interest			
Market orientation	Percentage of harvest sold to the market	0.28	0.12
Instrumental variables			
Premium on organic produce	If farmers receives premium on selling organic (yes = 0, no = 1)		
Knowledge about organic farming	Farmer is aware of what organic farming means (yes = 0, no = 1)		
Production diversity	No. of food crop groups grown	5.21	3.33
Distance to market	Time taken to reach preferred selling point	50.2	9.22
Collect market information	Farmer has access to market information (yes = 0,no = 1)		
Road type	(tarred roads =0, untarred roads =1, feeder road = 2)		
Mixed farming	Farmer engaged in mixed farming	0.87	–
Socioeconomic characteristics			
Gender	Male = 1; female = 0	0.21	–
Age of the respondents	Main occupation of the farmer (1 = Farming; 0 = Other occupations)	38	20.12
Education status	Number of years spent in formal education	9	3.01
Marital status	Single = 1, otherwise = 0	0.75	–
Family size	Number of individuals in a household eating from the same pot	0.71	–
Farm size	Size of land under cultivation	1.21	1.52
Land ownership	Ownership = 1, Rented = 2, Communal = 3, Borrowed = 4	–	–
Farming experience	Number of years in farming	17.5	12.6
Tropical livestock unit	livestock from various species converted to a common unit	3.25	1.02
Off-farm income	Money gotten from non-farm undertakings, gifts, or cash transfers (‘000 Naira)	75.0	51.01
No. of relatives	The number of close families the farmer can depend on at difficult times in a community	5.81	3.025
Access to development services			
Access to credit	If a farmer demanded credit and received the amount needed = 1, otherwise =0	0.62	–
Extension visits	Number of extension visits in the last farming season	3.33	2.1
Confidence in extension service	If the farmer has confidence in the skills of the extension agents	0.28	–
Group membership	Farmer belonged to a farm group = 1, otherwise = 0	8.22	–
State fixed effects			
Abia (yes = 0, no = 1)		0.20	–
Enugu (yes = 0, no = 1)		0.17	–
Ebonyi (yes = 0, no = 1)		0.26	–
Anambra (yes = 0, no = 1)		0.22	–
Imo (yes = 0, no = 1)		0.15	–

and the second is the extent of adoption (intensity of adoption). Following Danso-Abbeam, Dagunga and Ehiakpor (2019) we first conducted a diagnostic likelihood ratio test involving the estimation of probit, truncated and Tobit regression models to ascertain if the use of a 2-step procedure (Cragg's double-hurdle or Heckman) is justified. The probit model having $Y = 1$ for *organic farming adoption* adopters and $Y = 0$ for organic farming non-adopters is given as follows:

$$\mathrm{Y_i} = \Pr\left(\mathrm{Y_i} / \mathrm{Y_i}^* > 0\right) = \beta X_{\mathrm{i}} + \varepsilon_{\mathrm{i}} \tag{1}$$

Where Y^* represents the probability of adoption (latent variable). The truncated regression is presented in Equation 2.

$$\mathrm{Y_i} = \mathrm{E}\left(\mathrm{Y_i} / \mathrm{Y_i}^* > 0\right) = \beta X_{\mathrm{i}} + \theta_{\mathrm{i}} \tag{2}$$

where Y_i is the intensity of adoption (measured as the amount of land under cultivation that the farmer dedicated to organic food production) and Y_i is the adoption intensity latent variable. The 3rd equation is a combination of equations 1 and 2, representing the Tobit model.

$$yi = \left(\beta' X_i + \varepsilon_i\right) + \left(\lambda' Z_i + u_i\right) = \gamma' R_i + \wp_i. \qquad (3)$$

where β' and γ' are the $\wp$i parameter estimates of the independent variables for the truncated regression and probit models, respectively, whilst γ' characterizes the jointly estimated parameter estimates of the two models. Z_i, X_i, and R_i are the set of covariates with the associated ε_i, θ_i, and $\wp_i$ as the error terms for the truncated, probit, and Tobit regressions, respectively. From these three equations, the log likelihood ratios will be obtained and used to compute the Likelihood ratio test statistics:

$$\text{Lg} = 2\left(\text{LR}_{\text{probit}} + \text{LR}_{\text{truncated}} - \text{LR}_{\text{tobit}}\right).$$

Where Lg is the Likelihood ratio test statistics, $LR_{probit} + LR_{truncated} - LR_{tobit}$ are the likelihood ratios of the three models. Because our estimated Lg was found to be statistically significant and greater than the Chi-square distribution, we proceeded to employ the double hurdle model. To choose chose between Cragg's double-hurdle or Heckman, we considered the inverse mills ratio of the Heckman estimate. The coefficient of the inverse mills ratio which is the error covariance was found to be statistically insignificant indicating the absence of selectivity bias, hence the choice of Cragg's double-hurdle for this study.

3.3. Cragg's double hurdle

This study adopted the double hurdle model introduced by Cragg (1971) which involves a two-step process based on the idea that a farmer's decision to expand organic production is the result of two progressions. The first hurdle is determining whether the farmer adopted organic farming in the first place and the second hurdle is determining the extent to which the farmer adopted organic farming. Each of the stages involved represents the dependent variable of their hurdle equation. Following this idea, we developed two equations:

3.4. Participation equation (decision to adopt or not to adopt organic farming)

$$y^*_{1i} = x'_{1i}\,\beta_1 + u_{1i} \qquad (1)$$

y^*_{1i} is a dummy dependent variable (1 = adoption of organic farming; 0 = no adoption of organic farming) showing the organic farming adoption of the i^{th} farmer. x_i is a vector of the explanatory variables that adoption measured on the i^{th} farmer; β is a vector of coefficients of the explanatory variables; u_{1i} is the i^{th} error term.

3.5. Intensity of production equation (%)

This was measured as the amount of land under cultivation that the farmer dedicated to organic food production (in percentage). For instance, if a farmer uses the whole field for organic farming, the intensity of production is 100 percent. If the farmer only uses 50% of the land under cultivation for organic food production, we assign it 50 percent.

The determinant of the intensity of production is given as.

$$y^*_{2i} = x'_{2i}\,\beta_2 + u_{2i} \qquad (2)$$

Here, $y_{ji} = y^*_{ji}$ if $y^*_{1i} > 0$ and $y_{ji} = 0$ if $y^*_{1i} = 0$ if $y^* \leq 0$ for $j = 1, 2$.

Furthermore, the ordered pair (u_{1i}, u_{2i}) is taken from a bivariate normal distribution with mean zero and constant variances σ^2_1 and σ^2_2 with covariance $\sigma_{12} \neq 0$. By assumption, y_{1i} and y^*_{2i} are observed for as long as $y^*_{1i} > 0$ (i.e., both hurdles are crossed when the first hurdle is crossed) and y_{2i} is censored at zero when the first hurdle is not crossed (incidental truncation). Since the intensity of production is not a continuous variable, the standard OLS regression technique applied to the intensity of production is deemed to yield biased results. Hence, Cragg's model provided the basis for producing consistent parameter estimates.

3.6. Market orientation of farmers employing organic farming methods

We adopted the method employed in our previous analysis (see Ume, 2023) in estimating the market orientation of farmers employing organic farming methods. Here we estimated the quantity of major staple organic crops produced by the farmers as a ratio of all the crops the farmer produces. The crops estimated include: maize, rice, cassava, pumpkin, waterleaf, okra, red pepper, yellow pepper, white yam, three-leaved yam, tomatoes, potatoes, ukazi, and utazi. These were the crops that the farmers produced organically. We followed the definition of Frelat et al. (2015) in distinguishing food and cash crops where a crop C is a cash crop if 70% of total production is sold to the market. Since the products are calculated in percentage, it was easy to achieve a unit-less variable and allowed to lie between 0 and 1, with values toward 1 representing the more market-oriented a farmer is. The calculation of the index follows Gebremedhin and Tegegne (2012) as detailed in our previous study (Ume, 2023) and presented thus:

$$\alpha_C = \frac{\sum_{i=1}^{N} SCi}{\sum_{i=1}^{N} QCi};\; Q_{Ci} \geq S_{Ci} \; and \; 0 \leq \alpha_C \geq 1 \qquad (3)$$

Where;

α_C is the proportion of crop C that is sold.

Q_{Ci} is the total amount of crop C harvested or produced.

S_{Ci} is the amount of crop C sold to the market.

the Market Orientation index (MO_i) is then computed as follows:

$$MO_i = \frac{\sum_{C=1}^{C} \alpha CLiC}{L\frac{T}{i}};\; L\frac{T}{i} > 0 \; and, 0 < MO_i \leq 1 \qquad (4)$$

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Where;

$L\frac{T}{i}$ represents the total agricultural land cultivated by households i.

L_{iC} is the land that a farmer i allocated to crop C.

To categorize the farmers into market-oriented and non-market oriented the study used a cutoff point of 0.7. Any farmer that has a market orientation index of 0.7 and above is taken to be market-oriented (Hichaambwa and Jayne, 2012).

The parameter estimates for the double hurdle model are interpreted differently from the normal interpretation of the ordinary least square regression estimates. Here, we interpret the Average partial Effect (APE) of the expected values and probabilities which are calculated from the coefficients of the model. We calculated 3 different average partial effects which include the unconditional expected value expressed as [E (yi|x)]. This value is constructed from the conditional expected value expressed as [E (yi|x, y > 0)] i.e. the expected value of yi based on the independent variables x, a precondition that yi > 0, and the probability of a positive value for yi for the value of independent variables [P (y > 0|x)]. We used a bootstrapping method to develop the average partial effect coefficients and standard errors upon which we drew inferences.

4. Results and discussion

4.1. Descriptive statistics

In Figure 2, we present the descriptive statistics showing variation in the adoption and intensity of adoption of organic farming among smallholder farmers. The result showed that 33 percent of the respondents adopted organic farming. This finding is significantly higher than the global average of 0.5% (Global Organic, 2022), indicating an improvement in the level of adoption of organic farming in the study area. This lays credence to the fact that there has been a significant increase in policy and developmental action towards transitions to sustainable farming, especially in agrarian communities. There are also suggestions on the need to harness the different drivers to scale up the adoption of organic farming in developing nations (Ume et al., 2022). Among the 33 percent (415 farmers) of the farmers that adopted organic farming in the area, our findings showed that 76 of them dedicated between 80 to 100% of their land to organic farming. This distribution showed that attained a full or almost full transition to organic farming. This means only 6% of the entire sample attained a full or almost full transition to organic farming. Although this showed a growing level of adoption of organic farming aligning with the findings of Djokoto et al. (2016) who showed a growing number of organic cocoa farmers in Ghana. However, our findings also showed that the switch to organic farming has been in part and not a total transition, as only 6% of the entire sample attained a full or almost full transition to organic farming.

In Latin America and Europe, organic farmers, networks, and federations have grown rapidly, but these developments are often supported by national regulations and policies. This suggests that supporting organic farming and organic farming groups can help in the transition to a more sustainable and equitable form of farming. Such support can be in the form of favorable policies and programs that will motivate the farmers. Findings from this study suggest that market orientation and motivation of economic benefits can provide an entry point for designing policies that will lead to a sustained transition and scaling up organic production (Table 1).

4.2. Econometric findings

In this section, we present and discuss the findings based on Cragg's double hurdle model analysis. The results of the first and second-stage regressions are presented in Table 2. The result showed that premium on their organic products increases adopt organic farming by 2.81 and will also positively increase the land dedicated for organic production by 3.23 hectares. The proportion of land dedicated to organic farming was found to be 2.15 percent more for farmers that received a premium for their organic produce than their counterparts that do not receive a premium for their produce. Although there was no formal certification by any of the organizations listed in the Global Database on Certification Bodies maintained by The International Federation of Organic Agriculture Movements (IFOAM), in the study area, we found that some of the farmers have a way of branding their produce and in essence receive marginally increased profit from

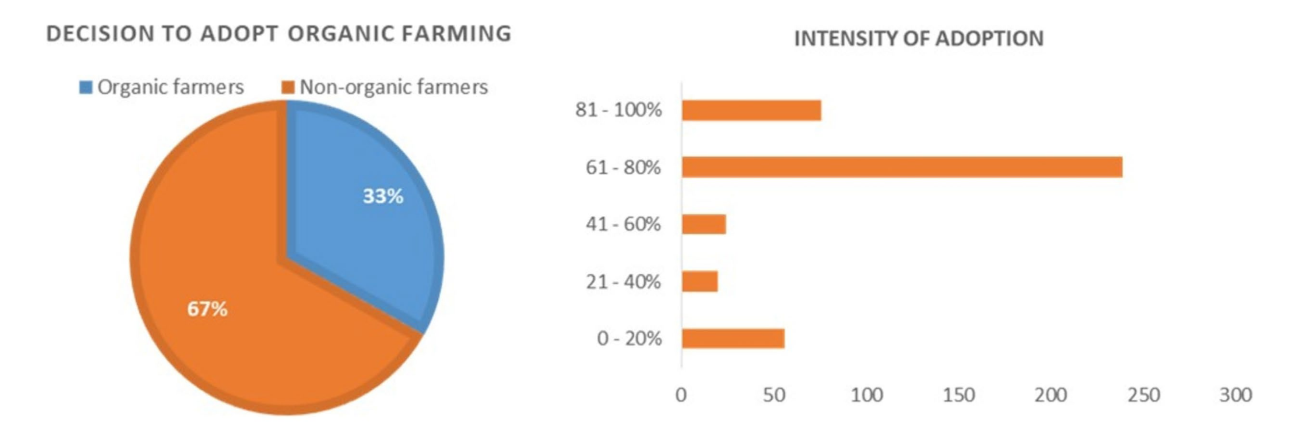

FIGURE 2
Decision to adopt and intensity of adoption of organic farming (Author).

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TABLE 2 Results of Cragg's double hurdle regression model for determinants of organic farming adoption.

	Adoption of organic farming (first hurdle)		Proportion of adoption (second hurdle)		Unconditional [E (yi|x)]		Conditional [E (yi|x, y > 0)]		Probabilities [P (y > 0|x)]	
	Coefficients (Robust Std. Error)	*Z*−values	Coefficients (Robust Std. Error)	*Z*−values	APE (Bootstrap std. Error)	*Z*−values	APE (Bootstrap std. Error)	*Z*−values	APE (Bootstrap std. Error)	*Z*−values
Premium on organic produce	2.81 (0.01)	3.41**	1.11 (0.21)	3.23***	0.21 (0.02)	2.03**	2.15 (0.101)	2.87*	0.23*** (0.41)	3.33**
Market orientation	1.67 (0.001)	1.62	1.22 (0.21)	2.43***	1.32 (0,31)	1.38	1.10 (0.05)	2.19**	1.22 (0.11)	1.41
Knowledge about organic farming	0.03 (0.17)	2.01*	0.15 (0.09)	2.14*	1.31 (0.21)	1.23*	−2.14 (0.52)	2.01*	3.21 (0.26)	1.78
Production diversity	6.02 (0.08)	0.02	0.20 (0.51)	0.21	0.66 (0.03)	1.32	1.56 (0.21)	0.14	2.35 (0.51)	0.32
Distance to market	−0.56 (0.05)	−0.21	−0.07 (0.21)	−2.31*	−0.39 (0.02)	−0.34	−0.12 (0.11)	−1.54	3.31 (0.26)	−1.52
Market information	1.12 (0.01)	2.56*	0.07 (0.79)	3.11**	−0.40 (0.10)	1.08	−2.87 (0.56)	2.87**	−2.3* (0.14)	2.25*
Road type	−0.75 (0.81)	−2.65**	−0.03 (0.05)	0.08	−0.77 (0.54)	−2.11**	3.24 (0.25)	0.54	1.45 (0.36)	−1.4
Mixed farming	4.65 (0.02)	0.01	0.27 (0.78)	2.52**	0.24 (0.12)	0.01	−2.21 (0.22)	2.11*	1.86 (0.16)	0.23
Gender	−2.24 (0.007)	−1.32	0.24 (0.12)	0.21	−0.36 (0.52)	−0.23	−1.21 (0.55)	0.12	−2.87 (0.07)	−1.17
Age of the respondents	2.25 (0.86)	1.40	−0.01 (0.001)	0.22	1.33 (1.02)	1.12	0.24 (0.21)	0.11	−1.01 (0.01)	1.32
Education status	2.35 (0.41)	0.01	2.35 (0.11)	0.97	0.36 (0.22)	0.01	0.35 (0.21)	0.54	2.11 (0.03)	0.01
Marital Status	−3.73 (0.005)	−1.1235	2.11 (0.01)	0.02	−2.29* (0.12)	−0.12	2.91 (0.01)	0.01	2.34 (0.21)	−0.45
Family size	4.18 (0.21)	0.15	1.73 (0.02)	−2.80*	−4.12 (0.12)	0.11	0.73 (0.005)	−2.43**	−2.81** (0.008)	0.21
Farm size	−1.96 (0.30)	−0.09	3.18 (0.20)	2.20**	−1.80* (0.15)	0.01	2.08 (0.95)	0.99*	−0.04 (0.57)	−0.03
Land ownership	2.35 (0.53)	2.02**	1.52 (0.70)	3.33***	3.20 (0.76)	2.00*	3.12 (0.002)	2.65**	−0.06 (0.85)	1.98*

(Continued)

TABLE 2 (Continued)

	Adoption of organic farming (first hurdle)		Proportion of adoption (second hurdle)		Unconditional [E (yi|x)]		Conditional [E (yi|x, y > 0)]		Probabilities [P (y > 0|x)]	
	Coefficients (Robust Std. Error)	*Z*−values	Coefficients (Robust Std. Error)	*Z*−values	APE (Bootstrap std. Error)	*Z*−values	APE (Bootstrap std. Error)	*Z*−values	APE (Bootstrap std. Error)	*Z*−values
Farming experience	1.53 (0.02)	2.57**	0.34 (0.14)	4.3**	0.36 (0.12)	1.21*	0.31 (0.08)	3.43*	4.65 (1.03)	2.34**
Tropical Livestock Unit	0.59 (0.05)	1.95*	1.21 (0.36)	0.12	−0.82* (0.02)	1.54	1.94 (0.07)	1.11	7.71 (0.21)	1.65*
Off-farm income	8.31 (0.214)	2.11*	3.85 (0.06)	0.02	−2.35 (0.02)	2.04*	3.20 (0.12)	0.23	3.52 (1.53)	2.01*
No. of relatives	5.21 (0.08)	0.12	−2.87 (0.07)	0.701	−1.90* (0.15)	0.11	−1.56 (0.51)	0.41	1.45 (1.01)	0.11
Access to credit	2.01 (1.23)	2.71**	1.01 (0.11)	0.56	2.76 (0.005)	2.49**	0.29 (0.02)	0.21	3.29 (1.45)	1.34
Extension visits	3.25 (0.08)	2.21**	2.11 (0.13)	4.01**	0.24 (0.12)	2.11*	2.06 (0.02)	3.21	1.73 (0.12)	2.16*
Confidence in extension service	1.56 (0.56)	2.02**	2.34 (0.21)	0.52	−0.01 (0.001)	2.02*	1.90 (0.003)	0.34	3.67 (1.20)	2.11**
Group membership	2.12 (1.02)	3.01***	7.21 (0.08)	5.21**	2.35 (0.41)	2.98***	7.102 (0.67)	4.23**	3.11 (0.56)	2.43***
State fixed effect	3.24 (0.28)	0.87	2.67 (0.11)	0.01	2.65 (0451)	0.45	−2.3 (0.14)	0.71	2.86 (0.16)	3.12**
Pseudo likelihood	112.71									
Wald chi[2]	82.56									
Prob>chi[2]	<0.001									

***, **, and *denote significance at 0.01, 0.05 and 0.1 level, respectively. APE, average partial effect. The sign value 2 denote 0.001.

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selling those products. However, the result also showed that more market-oriented farmers dedicate 1.10 percent more of their land to organic production than less market-oriented farmers. This relationship was also found to be statistically significant. The study found that farmers employing organic farming methods who dedicate more of their organic food for sales have more possibility of adopting organic farming than their counterparts who produce only for family consumption. What this suggests is that in evaluating the effectiveness of Agri-environmental programs, it is important to consider organic agriculture development and marketing simultaneously. The results further validate the idea that organic farming should not be viewed as an exclusive practice to the social activities of farmers and the cultural contexts in which they are embedded (Anderson et al., 2019; Calo et al., 2021; Ume et al., 2022). Organic marketing systems might bolster the efficiency of rural agri-environmental policies that facilitate sustainable agricultural practices among farmers if it is combined with agri-environmental policies that motivate them to produce commercially. Green labels and international certifications, for example, has the potential to improve profit and the broader welfare of small scale organic farmers in the developing nations (DeFries et al., 2017).

Market inefficiencies may explain the preference of some organic farmers to produce their own food. As production decisions ultimately translate into consumer decisions when markets are imperfect, then farm production will have a direct impact on consumer decisions when markets are imperfect (Wertheim-Heck et al., 2015; Kini et al., 2020; Usman and Callo-Concha 2021). If markets become efficient, farmers can produce food and sell surplus crops for enough profit to improve food security. Farmers can use profits to purchase food they are unable to produce. For farmers who use organic farming methods, there is a need for national policies and market development that encourage and facilitate local markets and exchanges.

Knowledge about organic farming was found to be a statistically significant determinant of the adoption and extent of organic farming among farmers. Farmers that have knowledge of what organic farming entails were found to be 1.31 percent more likely to adopt organic farming and to dedicate 1.23 percent more of their land to organic farming than the farmers that are less aware of organic farming. This finding can be tied to the relationship observed between extension visits and the adoption of organic farming. The number of extension visits was found to have a statistically positive influence on the adoption and level of adoption of organic farming among the farmers. This points to the role of extension and extension officers in the quest toward the transition to organic farming (Bellon et al., 2011; Silici 2014; Emeana et al., 2018). While extension visits will lead to a 0.2 percent increase level of adoption among the farmers, we found that among those who have adopted, extension visits will lead to a 2.06 percent increase toward total transition.

Our study showed that knowledge about organic farming significantly determined whether a farmer will adopt organic farming as well as the extent of organic farming adoption this is in line with the theory of adoption (Varajão et al., 2022), which postulates that awareness and knowledge is the first step toward the adoption of any technology. This finding suggests that farmers that have knowledge of what organic farming entails will be more likely to adopt organic farming and to dedicate a greater percentage of their land to organic farming than the farmers that are less aware of organic farming. This finding can be tied to the relationship observed between extension visits and the adoption of organic farming. This is because the extension agents are in a better position to communicate the methods and benefits of organic farming to these smallholder farmers. In assessing the role of public agricultural extension and advisory services in promoting organic transition in Southeast Nigeria, Osterholz et al. (2021) observed that farmers who adopted organic farming usually do so because they received the knowledge and saw the need for organic farming through information received from extension agents. Beyond the number of extension visits, our result shows that farmers' confidence in extension service plays an even more significant role in both the adoption and extent of adoption of organic farming. Apart from the knowledge of organic farming, our findings suggest that farming experience plays a significant role in determining the adoption and proportion of land dedicated to organic food production. This suggests that more experienced farmers will tend to adopt adopting organic farming than less experienced farmers. This positive relationship reinforces the need for better education in the quest for transition to an organic production system in the study area.

Our result showed that more experienced farmers have a 1.21 percent likelihood of adopting organic farming than less experienced farmers. In terms of the level of adoption, our result showed that more experienced farmers employing organic farming methods allocate 3.43 percent more land to organic farming than less experienced farmers. It is also important to highlight that experience of the farmer might not be connected to the age of the farmers as we did not find any statistically significant relationship between the age of the farmers and the adoption of organic farming.

Access to credit was found to significantly aid the adoption of organic farming but we did not observe any significant effect on the proportion of land the farmers employing organic farming methods dedicated to organic farming. This finding is in line with Olutokunbo and Ibikunle (2011) and Sapbamrer and Thammachai (2021) which highlighted the importance of financing investment in organic farming in the developing nation. The result showed that a 1% increase in the number of successful applications for loans and credit will lead to a 2.71% rise in the number of adoption. This relationship was found to be true for the rate of adoption. An increase in access to credit was also found to increase the rate of adoption by 101%, all other factors being equal. This finding is justified by the fact capital is required to make a switch from inorganic to organic farming and points to the fact that informal and formal credit systems will be necessary to achieve the goal of the organic farming transition. According to Sapbamrer and Thammachai (2021), farmers who operate under institutions that support farmers with soft loans and interest-free credits observed a more significant increase in the adoption of organic farming.

Finally, we observed that farmers with larger farm sizes have a negative effect on the adoption of organic farming. The coefficient of farm size was found to be −1.96. This means that a percentage increase in farm size decreased the rate of adoption by 1.96%, although this relationship was found to be statistically insignificant. Conversely, we found that a 1% increase in farm size will lead to a 3.18% increase in the amount of land dedicated to organic farming. This relationship was found to be statistically significant. This finding shows that although farmers with large farm sizes tend to be late adopters of organic farming, among the farmers employing organic farming methods, those with large farm sizes dedicated a greater proportion of the land to organic farming compared to farmers employing organic farming methods cultivating on smaller land sizes. Apart from the size of the land. The result showed that land ownership has a positive influence on both the adoption and intensity of organic production.

5. Conclusion and recommendations

In this study, we found that 33 percent of the respondents adopted organic farming. This finding is significantly higher than the global average of 0.5% (Global Organic, 2022), indicating an improvement in the level of adoption of organic farming in the study area. This finding shows a 200 percent increase from the figure reported in Emeana et al. (2018) 4 years ago. The result also points to the effectiveness of the agroecology movement in the study area in the diffusion of organic farming in the region. Furthermore, we empirically investigated the different drivers that affect the adoption and extent of adoption of organic farming by fitting data from rural Nigeria to a double hurdle model regression analysis. The result of the analysis in this study suggests that there exists a relationship between the socioeconomic characteristics of the farmers and the organic farming transition. Also, the result suggests that the action of the agroecology group in the study area has been effective in improving farmers' knowledge and adoption of organic farming. This study, therefore, adds to the body of literature unpacking the instrumental factors that need to be considered in scaling up organic farming in a developing nation's context.

Our econometric analysis showed that knowledge about organic farming, the experience of farmers, access to credit, and farm sizes are the factors that significantly determine the adoption and extension of the adoption of organic farming among smallholder farmers. Policymakers need to take these variables into account in devising strategies for an efficient transition to organic farming in the country.

Since knowledge about organic farming is important determinant of adoption of organic farming, there is a need for more advocacy and enlightenment on the importance, benefits and correct practice of organic farming among farmers. Policymakers should include organic farming as important part of extension services provided to farmers. Government also need to pay attention to younger and inexperience farmers as the study showed that experience farmers appear to adopt more of organic farming and dedicate larger portion of their lands to organic production. Credit was also found to be positively related to the adoption and level of adoption of organic farming. We therefore, recommend that credit should be made available for farmers to invest in organic production. This can be in the form of credit financing dedicated to organic farmers to encourage farmers to invest in organic farming. We also observed that farmers with larger farm sizes are less likely to adopt organic farming, however, we found farm size substantially increased the proportion of land a farmer dedicates to organic farming. This suggests that it might be easier for farmers who own their land, and hence, are in control of the land to make such a critical decision of making a switch from one production system to another. The prevailing land tenure system in the study area should take ensure private property right protects the smallholder farmers in owning their own lands. In addition, premium pricing was also a significant determinant of adoption demonstrating that policy actions aimed at certification among smallholder farmers employing organic farming methods can facilitate system-wise organic farming in rural areas. However, the nature of such certification that will not jeopardize the agency of the farmers requires further investigation.

Finally, our study has certain limitations. In the absence of longitudinal data, we were unable to properly infer causality of the hypothesized mechanisms due to the cross-sectional character of our data. As a result, we propose that future studies employ longitudinal data to first determine the situation of the outcome impact before, during, and after group participation. Secondly, in time series delaying and lagging causalities can be specified and better investigated.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://doi.org/10.6084/m9.figshare.20681653.

Ethics statement

The studies involving humans were approved by the Department of Agricultural Economics, University of Nigeria. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CU and NC-U: conceptualization. OO and UC: methodology. EO, CC, IC, and JC: formal analysis and investigation. BO and CC: writing – original draft preparation. BO and NC-U: writing – review and editing. CU, IC, and JC: funding acquisition. NC-U: resources. BO: supervision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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