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Policy support strategies for organic farming extensification in Nigeria

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Abstract To achieve a more sustainable agricultural production system, the focus should extend beyond solely promoting the adoption of organic farming to include an emphasis on extensification. A synergistic approach involving Branding/informal certification, price premiums for organic produce, and government subsidies holds the potential to drive higher levels of organic farming extensification among smallholder producers. This study encompassed 415 organic growers engaged in varying degrees of organic farming. These participants were drawn from the Southeast region of Nigeria. Employing a multi-endogenous instrumental variable regression, the research uncovered compelling insights. Notably, it revealed that providing premiums for organic products and utilizing Branding or informal certification significantly supported growers' inclination to expanding the land area under organic agriculture. Conversely, government subsidies exhibited a negative influence on extensification rates. In light of these findings, it becomes imperative to envision a more robust future for organic farming in Nigeria that hinges on strategic investments in formal certifications, thereby facilitating enhanced integration of organic producers into larger domestic and global markets.

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Introduction

Organic farming practices offers numerous environmental benefits. Organic farming reduces greenhouse gas emissions, minimizes water pollution, mitigates soil erosion, and promotes human health. Unlike conventional agriculture, organic methods prioritize carbon footprint reduction, soil health preservation and enhancement, and the restoration of natural ecosystems without the harmful residues of toxic pesticides (Familusi, Edriss, Phiri, 2023; Squalli and Adamkiewicz 2023). This transition is essential for sustainable and eco-friendly agricultural production. The Food and Agricultural Organization of the United Nations (2022) defines organic agriculture as:

> "*a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to using off-farm inputs, considering that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system.*" (FAO 2022)

Implicit in this definition of organic agriculture is the core principles it endeavours to uphold, including the promotion of biodiversity, the practice of recycling, the adoption of locally adapted farming systems, and the prioritization of human and environmental health., Organic agriculture seeks to minimize or eliminate the utilization of external inputs and the associated risks to the environment, human health, and animal welfare. These foundational principles and objectives underpin the distinctiveness of organic farming in its commitment to sustainability and ecological responsibility. In order to advance green economy initiatives within the global agricultural sector, it is imperative to advocate for the widespread extensification of organic farming practices (Squalli and Adamkiewicz 2023). Organic farming aligns with sustainability principles, environmental stewardship, and reducing ecological footprints, making it a pivotal component in fostering green economies worldwide. By championing organic agriculture, nations cannot only mitigate the adverse impacts of conventional farming methods but also promote healthier ecosystems, increased biodiversity, and the responsible use of natural resources, thus contributing to a greener and more sustainable agricultural future.

Organic farming can be promoted by encouraging farmers to adopt organic food production methods (Röös et al. 2018). Nevertheless, aside from simply embracing organic agriculture, it is imperative to prioritize the extensification (Kini et al. 2020). By dedicating more land to organic practices, we can extend these ecological advantages, contributing to sustainable agriculture and mitigating environmental degradation associated with conventional farming. " extensification " in the context of agriculture can indeed refer to dedicating more land to organic farming (Pretty et al. 2006). Still, it generally encompasses various practices and strategies aimed at increasing the productivity and efficiency of agricultural systems while minimizing negative environmental impacts (Mahon et al. 2018). It can involve crop rotation, organic fertilization, pest management, and soil conservation to make the most of existing agricultural land (Mahon et al. 2018). Within the context of this study, we use extensification to mean the size of farmland under organic cultivation and the number of organic practices employed from the following: crop rotation, organic fertilization, pest management, and soil conservation.

In most developing nations, there is still the need to provide incentives that will help farmers expand the use of organic growing methods. A study by Emeana et al. (2018) showed that less than 12% of organic farmers surveyed in a community in Southeast Nigeria engage in complete organic farming. In Ghana, Djokoto et al. (2016) reported that only about a thousand out of 18,425 surveyed farmers adopted complete organic agriculture in 2016. In terms of acreage under organic farming, only 0.905% acres of arable land is under organic farming (Yussefi 2006):However, in more developed economies, the figures appear to be much higher. For instance, in 2008, the United States had 10,903 complete organic farms covering around 4 million acres of farmland out of 342 million acres (1.65%) (Greene et al. 2010). In Europe, the total area under organic farming in the European Union as of 2020 covered over 14 million hectares of agricultural land out of 134 million hectares (10.45%) (Blaće et al. 2020).

Organic certification and government subsidies might provide vital mechanisms that can significantly contribute to expanding organic production among farmers in Nigeria (Ume et al. 2023). Organic certification serves as a hallmark of quality and adherence to organic farming principles, assuring consumers of the authenticity of organic products (Bui and Nguyen 2021). When farmers obtain organic certification, they gain access to premium markets and higher prices for their produce, providing a strong economic incentive for extensification. While extensive analytical work and research initiatives have been dedicated to promoting organic agriculture and sustainable farming in the global South as evidenced by the works of Chukwuma et al. (2016), who primarily focused on the socio-economic impacts of organic farming on rural livelihoods; Djokoto et al. (2016), who examined the environmental benefits of organic agriculture in mitigating soil degradation; Emeanaa et al. (2017), who explored the challenges and opportunities of transitioning to organic farming practices; FAO (2019), which provided an overview of policy frameworks supporting organic agriculture in developing countries; Priya and Singh (2023), who investigated consumer perceptions and preferences towards organic products; Brito et al. (2022), who analyzed the role of organic farming in biodiversity conservation; Organic Farming Research Foundation (2022), which focused on the technical aspects of organic

farming practices; and Priya and Singh (2023), who studied the market dynamics and potential for organic agriculture in the global South. Despite these valuable contributions, there remains a significant gap in the literature regarding comprehensive investigations into the economic incentives and government support systems, including certifications and subsidies, that are instrumental in scaling up organic agriculture within the global South. While existing studies have touched upon aspects of this issue, such as the environmental benefits and market opportunities associated with organic farming (as discussed in Sect. 4), there is a need for more in-depth research specifically focused on identifying and analyzing the specific economic incentives and government policies that can effectively promote the expansion of organic agriculture in this region.There is a noticeable gap in studies that have comprehensively explored if, and which economic incentives and government support systems, including certifications and subsidies, can be instrumental scaling up organic agriculture within the global South. This dearth of research hinders our understanding of the unique challenges and opportunities faced by agricultural practices in the global South, particularly concerning organic farming, and calls for increased attention to the economic and policy factors that could facilitate its expansion and extensification in these regions. It is this gap in knowledge that this study strives to fill.

In developed economies, the importance of certifcations in increasing organic farming is evident, and considerable research has investigated the role of government subsidies in organic production. However, reviews thus far reveal mixed evidence. For instance, a study by Lohr and Park, (2010) found that certified organic farmers in the United States earned higher returns per acre compared to conventional counterparts. Similarly, a comprehensive meta-analysis conducted by Willer et al., (2012) involving global organic agriculture trends emphasized the role of certification in enhancing market opportunities for farmers. Verburg et al. (2022) studied the case of organic dairy farming in the Netherlands and reported that government subsidies bolstered the economic feasibility of organic farming by offering financial support for organic certification fees, organic inputs, and infrastructure development. According to their findings, these subsidies reduce the financial barriers that farmers may face when considering expanding. Moreover, government policies that promote organic agriculture can encourage knowledge-sharing and capacity-building initiatives, fostering the growth of organic farming communities.

In contrast to the extensive literature on certifications and increased organic farming adoption in the global North, research on how to encourage full-scale extensification of organic farming by growers in the developing nation context is sparse. We were able to identify three studies (Janssen and Hamm 2012; Rizzo, Migliore, Schifani, 2023; Familusi, Edriss, Phiri, 2023). Janssen and Hamm 2012 reported that certifications serve as catalysts for sustainability improvements in the value chain in developing economies by providing brand assurance, promoting stakeholder satisfaction, encouraging the competitive development of certified supply volumes, and fostering dynamic capabilities within organizations. According to Rizzo, Migliore, Schifani, (2023), certifications benefit producers and contribute to a more sustainable and environmentally responsible global value chain. Familusi, Edriss, Phiri (2023) showed that certification policies aimed at transitioning agriculture to organic farming and extemsification need to enhance farmers' welfare, addressing economic, social, and environmental dimensions. These policies offer economic support, including subsidies and fair pricing mechanisms, to mitigate financial risks during the extensification. However, the authours opined that achieving these goals is complex due to the diverse needs and challenges faced by farmers, necessitating a comprehensive approach.

The present study used data collected in 2020–2021 from a large sample of eastern Nigeria farmers to assess if a combination of Branding and informal certification, price premiums for organic food, and government subsidies can collectively contribute to increased extensification of organic farming among smallholder farmers. The combination of this support system might help position smallholder farmers in developing economies towards a more formal certification system. In addition to the economic benefits, organic agriculture, supported by certification and Branding, aligns with broader sustainability goals (Moumouni, Baco, Tovignan et al. 2013). This alignment with sustainability objectives underscores the importance of support systems in incentivizing and scaling up organic production among farmers for economic prosperity and the long-term health of agricultural landscapes, especially in developing nations.

Intensification or extensification in organic agriculture

Intensification and extensification represent two contrasting pathways in the transition to organic farming practices, each with its unique implications. Intensification involves maximizing agricultural productivity within existing land areas through sustainable practices such as organic fertilization, crop rotation, and integrated pest management. These methods aim to enhance soil health, biodiversity, and ecosystem resilience while optimizing yields (Reganold and Wachter 2016). In contrast, extensification as employed in this study entails expanding organic farming onto new land areas, potentially incorporating previously uncultivated or degraded lands into agricultural production. While extensification may offer opportunities for scaling up organic agriculture, it also raises concerns about habitat conversion, biodiversity loss, and ecosystem degradation (Meyfroidt and Lambin 2011).

The choice between intensification and extensification pathways has profound implications for the transition to organic farming practices Intensification strategies prioritize improving the efficiency and sustainability of existing agricultural systems, offering potential benefits such as increased productivity, resource conservation, and climate resilience (Pretty et al. 2018). However, intensification must be carefully managed to avoid unintended consequences such as soil degradation or pest outbreaks. In contrast, extensification may provide opportunities to expand organic agriculture's footprint and reach new markets, but it also poses risks of environmental degradation and loss of biodiversity (Ponisio et al. 2015). By integrating principles of agroecology, organic farming seeks to optimize ecological functions while meeting human needs for food and fiber (Altieri 2018). This holistic approach recognizes the interconnectedness of ecological processes and human activities, emphasizing the importance of biodiversity, soil health, and ecosystem resilience in agricultural systems. As policymakers, researchers, and practitioners strive to promote organic agriculture, understanding the nuances between intensification and extensification pathways is crucial for developing context-specific strategies that balance productivity, environmental stewardship, and social equity in farming landscapes.

Status of organic farming and support policies in africa: A comprehensive overview

In this section, we provide an in-depth examination of the status of organic farming and the support policies available in Africa, with a focus on their implications for promoting organic agriculture in the study area. While certification plays a significant role in the organic farming landscape, we also recognize the importance of understanding the broader farm support policy environment in facilitating the transition to organic agriculture.

While certification remains integral to the organic farming sector, a broader understanding of farm support policies is essential for advancing the transition to organic agriculture in Africa. By addressing the existing disparities in subsidy allocation and promoting policies that incentivize organic practices, governments can create an enabling environment for organic farmers to thrive. A holistic approach that combines certification efforts with targeted support policies is crucial for realizing the full potential of organic agriculture and fostering sustainable food systems in the study area and beyond.

In many African countries, including the study area, government subsidies play a pivotal role in shaping agricultural practices. However, the current subsidy system often favors conventional farming methods, providing incentives for the use of chemical inputs and mechanization. This focus on conventional agriculture can hinder the transition to organic farming by creating financial barriers and perpetuating dependency on unsustainable practices (Akombi et al., 2017; Kilcher et al., 2018). Existing agricultural subsidies predominantly target conventional farming practices, offering support in the form of subsidized fertilizers, pesticides, and machinery. While these subsidies aim to increase agricultural productivity and food security, their alignment with conventional methods poses challenges for organic farmers. The limited availability of subsidies for organic inputs and practices further exacerbates the disparity between conventional and organic agriculture (Pretty et al. 2006; Agboola et al. 2015). One of the key challenges in promoting organic agriculture lies in the unequal distribution of subsidies and support mechanisms. Organic farmers often face financial constraints and lack access to affordable organic inputs, making it difficult to compete with conventional counterparts.

Table 1 Certification Bodies for Organic Agriculture in Africa

Certifcation	Descripton
Ecocert	Ecocert is a globally recognized organic certification body with offices and operations in several African countries namely: South Africa, Egypt, Tunisia, Morocco, Senegal, Madagascar, Ivory Coast. They certify organic products based on international organic standards and provide verification services for organic farmers and producers
Organic Farmers and Growers (OFG)	OFG is a certification body operating in various African countries, including South Africa. They specialize in certifying organic and sustainable farming practices, ensuring products meet the highest organic standards
IFOAM Organics International	IFOAM is a global organization promoting organic agriculture. They work with various certification bodies and organizations in Africa to ensure that organic practices align with international standards and principles. They mostly in the Southern African countries namely: Angola, Botswana, Democratic Republic of the Congo, Lesotho,Madagascar, Malawi, Mauritius, Mozambique, Namibia, Swaziland, Tanzania, Zambia, Zimbabwe, South Africa, and the Seychelles
Afrisco Organic Certification Agency	Based in Uganda, Afrisco is an organic certification agency that provides certification services for organic farmers and producers across the African continent.`
Bioland	Bioland is an organic certification organization primarily active in North African countries. They work to certify organic products and support sustainable agriculture practices
Control Union Certifications (CUC)	Control Union Certifications is a global certification body with offices and operations in multiple African countries. They offer organic certification services and promote sustainable agricultural practices
Soil Association Certification	The Soil Association is a UK-based organization, but they work with certification bodies in Africa to provide organic certification services for various agricultural products, including fruits, vegetables, and textiles
NOPE (Nakuru Organic Producers Enterprises Ltd.)	Based in Kenya, NOPE is a leading organic certification body in East Africa. They certify organic products produced by smallholder farmers and cooperatives
IMO (Institute for Marketecology)	IMO is an international organic certification organization that operates in Africa. They provide certification services for organic and sustainable agriculture, including Fair Trade certification
Fairtrade Africa	While not exclusively an organic certification body, Fairtrade Africa works with organic and sustainable farming practices in various African countries. They focus on promoting fair trade principles and practices

Source: *Authours*

Additionally, bureaucratic hurdles and inadequate infrastructure may impede the effective implementation of organic farming support policies (Paull 2019; Klerkx et al. 2010).

Similarly, certification serves as a critical mechanism for verifying organic farming practices and ensuring compliance with international standards. Across Africa, efforts to establish and expand organic certification schemes have been underway, aiming to enhance market access and promote consumer confidence in organic products. However, it's imperative to acknowledge that certification alone may not address all barriers to organic farming adoption, particularly in regions where farm support policies heavily influence agricultural practices (Waweru et al. 2019; Rogé et al. 2020). Table 1 provides comprehensive details of certification bodies for organic agriculture in Africa, ensuring organic farming practices meet the required standards and regulations. The description shows that apart from Ecocert and IFOAM Organics International which are international certification bodies, the rest of organic certification bodies are locally organized. Recently, Several African governments have shown commitment to promoting organic agriculture through policy support and subsidies. For instance, countries like Tanzania have implemented programs to encourage organic farming practices among smallholders (Farrelly 2016). Subsidies play a pivotal role in nurturing organic farming across Africa, gaining recognition from both governments and international organizations. Organic agriculture

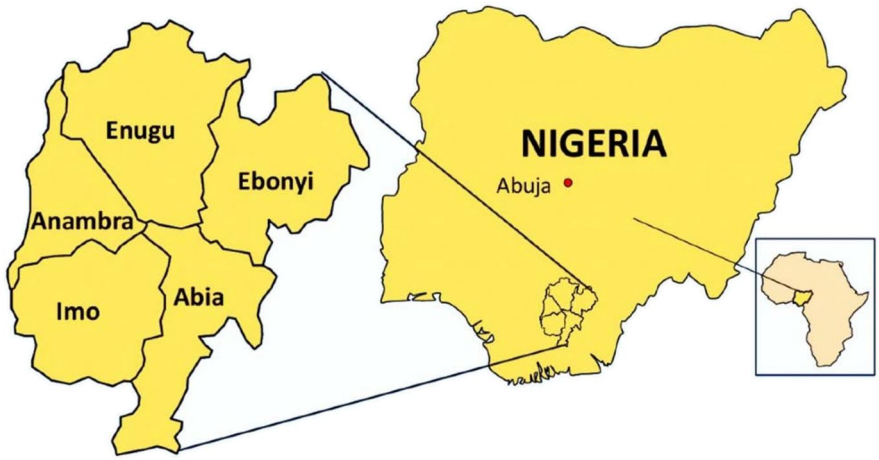

Fig. 1 Map of South-east Nigeria showing the research areas

is seen as a means to bolster food security, promote sustainable farming practices, and enhance livelihoods in a region where agriculture often serves as a primary source of income. Subsidies, delivered through financial incentives, technical support, and capacity-building programs, serve as a catalyst for farmers looking to invest more in organic farming. By mitigating some of the initial economic barriers and risks associated with this shift, subsidies contribute to expanding the organic market while fostering environmental sustainability.

Hypothesis development

Several studies have examined factors that could motivate farmers to move from conventional to organic farming under different contexts (Kubala et al. 2008; Komakech et al. 2014; Yazdanpanah et al. 2014; Wang et al. 2015; NING et al. 2017; Dalmiyatun et al. 2018). For example, Wei et al. (2022) identified cooperative societies as one of the promoters that could assist more than 200 million farmers in China in adopting green farming practices. Wang et al., (2018) examined what could encourage farmers to replace chemical fertilizers with organic fertilizers. The authours submitted that a farmer's choice of organic fertilizers over chemical fertilizers is influenced by subsidies for organic fertilizers and the farm size. From the demand side, Tandon et al., (2020) investigated why people buy organic food and identified environmental concerns and trust as the main drivers. The authours also submitted that external and Integrated regulations significantly affect whether individuals want to buy organic food. Following the recognition of the importance of both external factors and intrinsic human values in the organic farming extensification, it is, therefore, essential to understand which combination of support systems will help smallholder farmers adopt organic farming, thereby providing a more robust knowledge base that will inform organic agriculture policies and programmes.

This study presents three testable hypotheses (H) related to the study's Research Questions (RQ).

RQ1 and H1: How will Branding and informal certification impact the extensification of organic farming? In the study area, some organic farmers employ informal Branding strategies to market their products and appeal to potential consumers (Ume 2023). Therefore, the study postulates that such Branding efforts could lead to price premium and increased income generation for the farmers, thereby incentivising more farmers to switch to organic farming. Branding and informal certification can enhance the perceived value and marketability of organic products (Ayuya 2019). When smallholder farmers engage in Branding, they create a distinct identity for their products (Fig. 1), emphasizing their organic and healthy qualities. This can attract consumers who are willing to pay more for certified organic products. Additionally, informal certification, such as transparent labeling or community recognition, can provide assurance

to consumers and fellow farmers that organic practices are being followed. This builds trust and encourages more farmers to adopt organic methods, as they see the benefits of differentiation and higher prices for their produce.

RQ2 and H2: How will price premium for organic food impact farmers' decisions to embrace organic farming practices? This study posits that there is a positive correlation. Offering a price premium for organic food incentivizes farmers to adopt organic practices. When farmers receive a higher price for their organic products compared to conventional ones, it directly enhances their income (Moscovici et al. 2022). Typically, consumers who strongly understand the quality and standards associated with organic food are willing to pay extra for organic products (Janssen and Hamm 2012). Therefore, the study suggests that a premium on organic goods can translate into higher earnings for producers to extend the area of land dedicated to organic farming methods. This financial incentive serves as a reward for the additional effort and resources required for organic farming. Smallholder farmers, often operating on limited budgets, are more likely to expand organic farming when they see the potential for increased profitability. Examining this connection can offer valuable insights into the feasibility of implementing certification procedures that not only enable organic farmers to access international markets but also guarantee premium prices for the farmers (Atoma et al. 2020).

RQ3 and H3: How will government subsidies result in an increased extensification of organic farming? We anticipate a positive correlation between government subsidies and the extensification of organic farming practices (Puntsagdorj et al. 2021). Government subsidies are expected to boost the extensification of organic farming due to financial incentives, risk mitigation, and support for sustainable agriculture. These subsidies reduce the financial burden on farmers, provide a safety net during the extensification period, and align with environmental sustainability goals (Puntsagdorj et al. 2021). Additionally, they facilitate market access and respond to growing consumer demand for organic products.

Methodology

Study area and data

The study focused on the Southeastern geopolitical region of Nigeria, which is one of the country's six geopolitical zones. This region encompasses five states: Imo, Enugu, Ebonyi, Anambra, and Abia (Onyekuru et al. 2020). It experiences a tropical monsoon climate, situated between latitude 23° 27' North to 23° 27' South, and receives an annual rainfall ranging from 2,000 to 3,000 mm (118.1 in) (Ume et al. 2020). The primary language spoken in the area is Igbo, which is prevalent among the local population. Igbo is a major language in Nigeria, particularly in the Southeast region, and it is spoken by approximately 22 million people (National Population Commission (NPC) [Nigeria] and ICF International, 2022). The rural communities in this region are predominantly engaged in agriculture, with farming as their primary occupation. Data for this study were collected between September 2020 and July 2021. The data was collected by the Agroecology Center, a collaborative initiative formed by researchers from the University of Nigeria and the Center for Agroecology, Coventry University, including the first author of this paper. The primary aim of the Agroecology Center is to extend agroecological innovation to farmers and assess the effectiveness of sustainable farming practices in the region. While the data was not collected specifically for this study, it was gathered to monitor the status of agroecology transition in the area and evaluate the impact of the center's initiatives. The dataset proved to be suitable for the current study, allowing for an in-depth analysis of factors influencing the transition to organic agriculture among smallholder farmers. The data has been used in our previous publication in the Journal of Cleaner production (Ume 2023) in understanding the role of market in organic farming transition.

Sampling method

The data collection process employed a multistage sampling technique. In the initial stage, the study purposefully selected the five Southeast Nigeria states: Abia, Enugu, Anambra, Ebonyi, and Imo state (Fig. 1). This selection was primarily based on

convenience, considering the region's accessibility and the researchers' familiarity with the area. Additionally, this region was chosen because it is where the agroecology movement originated, increasing the likelihood of sampling farmers who engage in organic farming practices. In the second stage, all the local government areas (LGAs) within the respective states were included in the survey. This encompassed 17 LGAs in Abia state, 27 LGAs in Imo state, 13 LGAs in Ebonyi state, 21 LGAs in Anambra state, and 17 LGAs in Enugu state, totaling 95 local government areas[1] covered.

For the final stage, the survey collected data from 15 farmers in each of the 95 LGAs. After data cleaning, which involved removing incomplete responses, the dataset consisted of 1,253 farmers in total. Among these, there were 415 farmers practicing various levels of organic farming, while 838 adhered to conventional farming methods. Only the organic farmers' data were utilised for the study. It's important to note that the survey exclusively focused on smallholder farmers, and their classification followed the criteria set by the FAO (2020). According to the FAO definition, a farm household is considered a smallholder when it manages a land area of less than 5 hectares.

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 farmers and the level of extensification of organic farming. Organic farming was measured using the dichotomous dummy of 0 and 1, where 1 represents farmers who adopt any form of organic farming and 0 otherwise. To understand farmers Willingness To Pay (WTP) for formal organic certification (Such as EcoCert), the data provided a second questionnaires only for the organic farmers to understand their preferences and their willingness to invest in organic certification. Participants are asked directly how much they would be willing to pay for a specific item or attribute.

[1] Local government areas (LGAs) in Nigeria vary significantly in size, but they typically cover an area ranging from approximately 200 to 5,000 square kilometers.

Econometric approach

Multiple instrumental variable regression

This study employs a multiple instrumental variable regression analysis to capture the effects of price premiums on organic produce, government subsidies for organic farmers, and Branding/informal certification on the extensification and extension of organic farming. One common endogeneity issue is reverse causality, where the outcome variable (organic extensification) affects one or more of the explanatory variables. For example, farmers who have already adopted organic practices may have different characteristics and motivations compared to conventional farmers, and these characteristics can affect their decisions regarding factors like government subsidies and Branding, or willingness to pay for certification. Also, the extensification of organic farming practices and factors like Branding and government subsidies, can be jointly determined. Farmers may choose to adopt organic practices based on the availability of subsidies or market demand for organic products, and at the same time, these factors can be influenced by the extent of organic extensification in the area.

The research begins by specifying the instrumental variable regression model, aiming to understand the impact of price premiums on organic produce, government subsidies for organic farmers, and Branding/informal certification on the extensification of organic farming. This model encompasses various variables of interest:

$$Y_i = \beta_0 + \beta_1 \cdot X_{PricePremium,i} + \beta_2 \cdot X_{Subsidies,i} + \beta_3 \cdot X_{Branding,i} + \beta_4 \cdot X_{Controls,i} + \epsilon_i$$

Here, Y_i denotes the extensification organic farming for each farm under study. The model includes several explanatory variables:

$X_{Price}Premium,i$	Represents the price premium for organic produce observed for each farm.
$X_{Subsidies},i$	Indicates the government subsidies allocated to organic farming for each farm.
$X_{Branding},i$	Reflects whether each farm employs Branding or informal certification.

$X_{Controls,i}$ Encompasses relevant control variables, such as farm size, location, and other pertinent factors.

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ correspond to the regression coefficients that quantify the relationship between these variables.

ϵ_i represents the error term accounting for unexplained variations.

Instrumental variables

Previous studies usually utilize the two stage assessment, whereby the first stage is to account for the likelihood of adoption of organic fdarming, before assessing the determinants of extent of adoption. However, because our sample utilizes cross-section of adopters, there is no longer the necessity of determining the likelihood of adoption since all respondents are already adopting vcarious levels of organic farming. The determinants of adoption has been well documented in our previous studies using the same dataset (See: Ume et al 2023).

To account for potential endogeneity issues, the research identifies instrumental variables (IVs) that meet the criteria of relevance and exogeneity. These IVs should exhibit correlation with the endogenous variables (i.e., price premium, subsidies, Branding) while remaining unrelated to the extensification of organic farming. The chosen three instrumental variables are represented as Z_i., and include the following: access to market, distance to government agricultural offices, and access to organic farming training programs as instruments for the respective varaibles of instreat (price premium, subsidies, Branding).

To rectify potential endogeneity concerns, the instrumental variables are employed to adjust the estimation of coefficients for price premium, subsidies, and Branding. Because we have three endogenous explanatory variables, we will have three reduced forms in the first stage regression. This entails constructing instrumental variable estimation equations:

$$X_{PricePremium,i} = \alpha_0 + \alpha_1 \cdot Z_i + \eta_i$$

$$X_{Subsidies,i} = \gamma_0 + \gamma_1 \cdot Z_i + \theta_i$$

$$X_{Branding,i} = \delta_0 + \delta_1 \cdot Z_i + \xi_i$$

Here, α_0, γ_0, δ_0 denote the intercepts of the instrumental variable estimation equations, while α_1, γ_1, δ_1 signify the estimated coefficients connecting the instrumental variables to the endogenous variables. The error terms η_i, θ_i, ξ_i account for unexplained variations in each instrumental variable equation. Addressing the endogeneity issue is crucial in empirical research on organic extensification to ensure that the estimated effects of factors like government subsidies, Branding, or certification on extensification are unbiased and reflect true causal relationships.

Following the development of instrumental variable equations, the research proceeds to estimate the instrumental variable regression model. This analysis incorporates the corrected endogenous variables and incorporates control variables (Table 2). Diagnostic tests are conducted to evaluate the validity of instrumental variables. These tests include examining the F-statistic for instrument relevance and verifying instrument exogeneity to address potential endogeneity issues effectively.

Relevance test (First Stage F-statistic)

The relevance test assesses whether the chosen instruments are statistically significant in explaining the endogenous variable (e.g., government subsidies, Branding, or certification). In other words, it checks if the instruments have a strong relationship with the variable that is potentially endogenous (e.g., extensification of organic farming). We estimated the first stage regression, where the potentially endogenous variable (e.g., organic extensification) is regressed on the instrument(s). The F-statistic, which measures the strength of this relationship, is calculated. A high F-statistic suggests that the instruments are strongly related to the potentially endogenous variable. This was desirable because it indicates that the instruments provide sufficient variation in the endogenous variable to identify its causal effect.

Exogeneity test (Instrument Validity)

The exogeneity test examines whether the instruments are exogenous, meaning they are not

Table 2 Definition and descriptive statistics of exogenous outcomes and control variables

Variables	Description	Mean	Std dev
Outcome variables			
Organic farming	percentage of land dedicated to organic farming and the number of organic practices adopted	44%	12.4
Variables of interest			
Premium on organic produce	If farmers receive a premium on selling organic (yes = 0, no = 1)		
Government subsidies for organic farmers	farmer has received any form of subsidy (yes = 0, no = 1)		
Branding and informal certification	Farmer employed any form of product differentiation (yes = 0, no = 1)		
Other variables			
Knowledge about organic farming	Farmer is aware of what organic farming means (yes = 0, no = 1)		
Farmer group or cooperative society	Farmer belonged to any cooperative society (yes = 0, no = 1)		
Environmental concerns	Buyer purchases as a result of environmental concerns (yes = 0, no = 1)		
Market orientation	Percentage of harvest sold to the market	0.28	0.12
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	Farmers engaged in mixed farming	0.87	-
Socioeconomic characteristics			
Gender	Male = 1; female = 0	-	-
Age of the respondents	Years	38	20.12
Education status	Number of years spent in formal education	9	3.0.1
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 standard unit	3.25	1.02
Off-farm income	Money gotten from non-farm undertakings, gifts, or cash transfers ('000 Naira)	75	51.01
Access to development services			
Access to credit	If a farmer demanded credit and received the amount needed = 1, otherwise = 0	-	-
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	-
Abia (yes = 0,no = 1)		-	-
Enugu (yes = 0,no = 1)		-	-
Ebonyi (yes = 0,no = 1)		-	-
Anambra (yes = 0,no = 1)		-	-
Imo (yes = 0,no = 1)		-	-

correlated with the error term in the regression model. If instruments are correlated with the error term, it can introduce endogeneity bias.

The key idea is to compare two estimation methods: IV and OLS (Ordinary Least Squares). The test statistic, often denoted as S, is calculated as:

$$S = \left(\beta^{IV} - \beta^{OLS}\right)\prime\left[Var\left(\beta^{IV}\right) - Var\left(\beta^{OLS}\right)\right] - 1\left(\beta^{IV} - \beta^{OLS}\right)$$

Where:

β^{IV} is the coefficient estimate from the IV regression.

β^{OLS} is the coefficient estimate from the OLS regression.

$\mathrm{Var}(\beta^{IV})$ and $\mathrm{Var}(\beta^{OLS})$ are the variance–covariance matrices of the coefficient estimates.

The test statistic S can be compared to a critical value from the chi-squared (χ^2) distribution with degrees of freedom equal to the number of instruments to assess instrument validity. The significance of the exogeneity test indicates that the instruments are valid and meet the crucial IV assumption of instrument exogeneity. In other words, it suggests that the instruments we employed are not affected by unobserved factors that could simultaneously influence the endogenous variable.

To enhance the robustness of findings, sensitivity analyses are conducted to test the model's stability concerning variations in instrumental variables and model specifications. The sensitivity analysis involves systematically varying key parameters within the model to assess the robustness of the results. In our context, the sensitivity analysis helped us evaluate the extent to which the estimated effects are influenced by different modeling choices and assumptions. To do this, we varied the strength of instruments. Here we assessed how changes in the strength of the instruments (by reducing and increasing the first-stage F-statistic) affect the results. Our results remained consistent across a range of sensitivity tests and model specifications, enhancing the confidence in the validity of the conclusions drawn from the IV regression (Fig. 2).

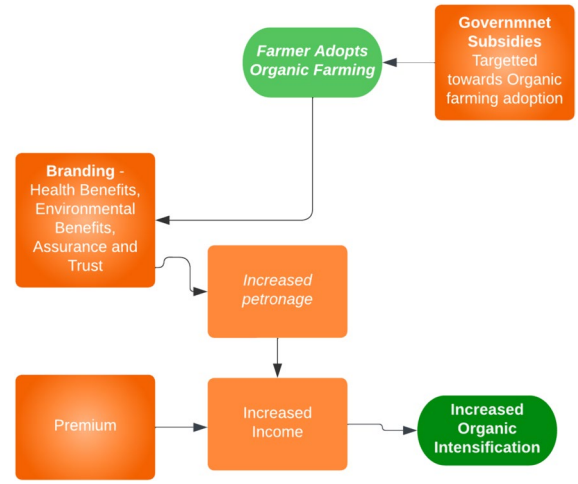

Fig. 2 Conceptual framework of the effect of Branding, price premium, and subsidies on organic agriculture extensification. (Source: Authours)

Empirical results

Levels and forms of organic farming extensification among farmers

The study categorized farmers in the area into three distinct levels of organic farming extensification, as depicted in Fig. 3. The first level comprises farmers who adhere strictly to conventional farming practices and do not incorporate any form of organic farming methods. These farmers are referred to as "conventional farmers" in this study. Notably, our findings revealed that a significant majority of surveyed farmers, constituting 67% of the total, fall into this conventional farming category. This set of farmers were not used in this study. Only the organic farmers were used in the study. Conversely, the second level encompasses farmers engaged in "integrated organic farming," which represents 7% of the surveyed farmers. Integrated organic farming involves the implementation of a cyclical and waste-minimizing approach. In this method, waste products generated during one stage of farming are efficiently repurposed as nutrients for subsequent stages. This approach optimizes resource utilization and enhances overall production efficiency. The third and final level comprises "pure organic farmers,"

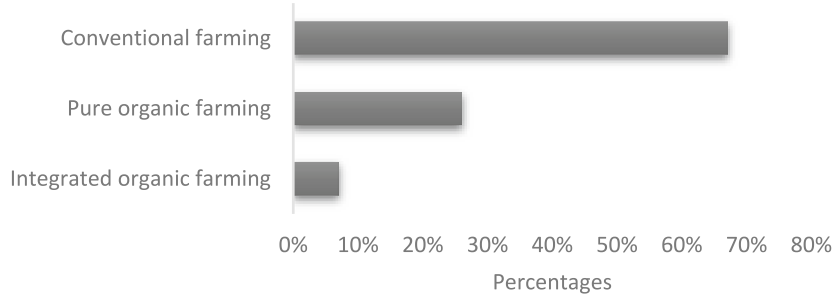

Fig. 3 Types of farmers with respect to forms of organic farming practices employed

representing 26% of all surveyed farmers and constituting 79% of organic farmers within the study (n = 415). Pure organic farming entails the utilization of organic inputs in agricultural practices, which may or may not originate from within the farming enterprise. This approach prioritizes the use of organic materials and methods to a significant extent.

The data further reveals interesting patterns among organic growers in terms of their farming practices:

Exclusive Organic Production (37%) A significant portion, roughly 37%, of organic growers exclusively engage in exclusive organic production. This suggests a strong commitment to organic farming principles, where all their cultivated land is dedicated to organic practices. These growers likely prioritize sustainability and may cater to a niche market that values purely organic products.

Partial Organic Cultivation (20%) About 20% of organic growers allocate 50% of their land for organic farming. This group appears to be practicing a hybrid approach, possibly balancing organic and conventional farming methods. Their willingness to allocate half of their land to organic farming may indicate a growing interest in organic practices without a complete adoption.

Limited Organic Cultivation (43%) The majority, comprising 43% of organic growers, utilize less than half of their land for organic farming. This group appears to be taking a cautious approach, possibly experimenting with organic methods on a smaller scale or incorporating them alongside conventional farming. Their allocation of less land to organic farming suggests a gradual extensification or a mix of farming strategies.

These findings illustrate a diverse landscape within the organic farming community. While a notable portion fully embraces organic practices, others are exploring a range of approaches, indicating the complexity and evolving nature of the organic farming sector. Understanding these variations can be crucial for policymakers, researchers, and stakeholders in supporting and promoting sustainable extensification of organic production.

Which support mechanisms will help scale up organic production in developing nations?

This section will discuss the findings derived from instrumental variable regression analysis, specifically focusing on three key variables: price premium, subsidies, and Branding (Table 3). For a more comprehensive presentation of the regression results, including covariates, please refer to Table 7 in the Appendix. Our findings suggest that promoting organic certifications, including the presentation of organic products with appealing and health-focused Branding, along with improvements in farmers' selling prices, can significantly encourage the extensification of organic farming. Two sets of findings substantiate this hypothesis (Fig. 4).

The results, as presented in Table 3, indicate that when we keep all other predictor variables constant, there is a 53% increase in the likelihood of farmers adopting organic farming when they receive a premium for their products. This premium refers to additional charges farmers add to the price of their commodities, resulting in increased income. Notably, the coefficient for the premium price variable is statistically significant at a 0.01 level of significance, reinforcing its importance in influencing farmers'

Table 3 Effect of price premium, Branding and subsidies on organic farming extensification

Variable	Coefficient	Std. error	t-values
Premium on organic produce	0.53	0.0049	2.25**
Branding and informal certification	0.401	0.7421	3.13**
Government subsidies	-0.65	0.0040	-3.01**
Premium*Branding *(Interracted)*	0.76	0.0031	7.09***
Controls	√	√	√

Wald chi2 = 63.56; Prob> chi2 = 0.0001; Log likelihood = -725.21316

This table collects results for specifications following equation 1 and 2 of the 2-stage least square regression. We tested whether these three indicators will lead to an increase or decrease in organic farming extensification. The coefficient indicates the magnitude of change result from the independent variables. The instruments employed for three variables of interest are access to the market, access to organic farming training programs, and distance to government agricultural offices. Results with control variables are presented in the Appendix. Stars indicate significance levels at 10%(*), 5%(**) and 1%(***).

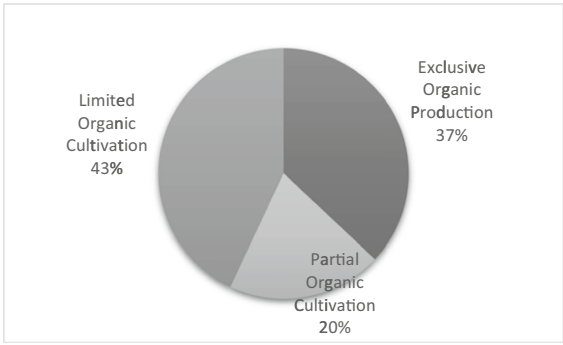

Fig. 4 Levels of organic farming extensification

decisions to adopt organic farming practices. These findings align with research conducted in other regions. For instance, Oberholtz et al. (2005) highlighted the significance of price premiums in expanding the U.S. organic produce market. Similarly, Park and Lohr (1996) emphasized the role of farm prices in determining wholesale markets for organic carrots, broccoli, and lettuce.

Regarding Branding and informal certification results, the instrumental variable regression analysis indicates that the probability of adopting organic farming increases by approximately 40% for farmers who employ some form of Branding and informal certification. In this study, the terms "Branding" and "certification" are used broadly to encompass farmers who package their products and emphasize the advantages of organic food. This aligns with the perspective of the Food and Agricultural Organization of the United Nations (FAO 2007), which highlights how certification and Branding can take different forms of informalities. According to Padilla Bravo, Villanueva Ramírez, Neuendorff (2013), certification could also enhance product value, allowing organic producers to command premium prices and access new domestic and export markets. Such Branding offers a competitive edge to farmers. Lehner and Halliday (2014) further explored the growing significance of ethical Branding in addressing institutional limitations within existing organic market structures in many countries. Their research underscores how organic Branding can facilitate value co-creation and the incorporation of sustainable consumption into retailer-customer interactions. This approach has become a favored strategy for retailers seeking to meet societal demands for more proactive corporate behavior.

To understand the effect of the combining premium pricing and Branding, we interacted the two variables. The integration represents the farmers who combined premium pricing and Branding. The result showed that producers who both receive a premium on their products and engage in Branding their products are more likely to adopt organic farming practices compared to producers who only do one of these actions or neither. The coefficient of 0.76 indicates a positive correlation between the combination of premium pricing and Branding and the likelihood of adopting organic farming practices. In other words, when producers receive a premium for their products and also invest in Branding, they are 0.76 times more likely to adopt organic

Table 4 F–Test for Weak Instrumental Variable (Instrument Relevance)

Null Hypothesis	H_0: Included instruments are weak instrument
Minimum Eigenvalue Statistic	15.712
p-value (Probability > F)	0.001
Critical F Statistic Value	1249.28
Level of Significance	1%

farming practices compared to those who do not follow this combination. The result suggests that the joint strategy of premium pricing and Branding appears to be more effective in promoting organic farming extensification among producers when compared to either strategy employed individually.

Our findings reveal that farmers who receive subsidies from the government exhibit a lower tendency to adopt organic farming. As illustrated in Table 3, farmers who benefitted from government subsidies were 6.5% less likely to engage in organic farming practices. This outcome aligns with expectations since most government subsidies typically take the form of fertilizers and improved seeds associated with conventional farming methods (Ume et al. 2020).

Relevance and endogeneity test

A poor IV magnifies the bias in Instrument Variable (IV) estimation (Wooldridge, 2014) thus there is a need to test for the strength of the instrumental variable. From the Table 4, the minimum Eigen F – statistic value of 15.712 with a p – value of 0.001 shows that the instrument variables are strong instruments, hence the null hypothesis for a weak instruments are rejected at 1 percent significance level. This is also given to the overly small probability and a high minimum Eigen value exceeding the critical value that is only 9.28 in magnitude. The rejection of the null hypothesis of a weak instrument revealed that the instrument variables passed the instrument relevance test, which is also consistent with the reduced form result from the first stage regression (Appendix 1, Table 6). Evidence from the reduced form first stage regression further points to instrument relevance of access to the market, access to organic farming training programs, and distance to government agricultural offices as the coefficient estimate on the instrument variables turned up statistically significantly different from zero and consistent with theoretical postulates (apriori expectation).

The Hausman test for endogeneity is a test that reveals whether or not the perceived endogenous variable is truly endogenous. Endogeneity is often a serious problem in estimating regression results as it could lead to a spurious outcome should OLS be applied to the regression in the presence of endogenous regressor. Similarly, if the variables of interest were to be exogenous, using IV estimation gives us a consistent but inefficient estimator, but OLS is BLUE (Best Linear Unbiased Estimator). Hence, there is a need for a test for endogeneity to ascertain whether or not the Two Stage Least Squares/ Instrument variable technique would be adopted as against the OLS technique.

From Table 5, we observed that the p–value for the Hausman test is 0.001 and the Durbin score is 0.0081, which is indicative of the rejection of the null hypothesis of no endogenous variable at 1 per cent level of significance with a t–values of 2.66 and 7.21 approximated from an f – value with single restriction. This shows that the variables of interest in the regression model are endogenous. Thus, adopting the Two Stage Least Squares/ Instrument variable estimation technique in estimating the impact of organic farming extensification becomes appropriate.

Table 5 Summary of Statistical Tests for Endogeneity and Autocorrelation

Test	Statistic	Degrees of Freedom	P-value	Conclusion
Hausman Test	2.66 (approximated from f-value with single restriction)	1	0.001	Reject null hypothesis at 1% significance level
Durbin Score	0.0081	-	-	-

Discussion

The findings from this study revealed a significant and positive relationship between receiving a premium for organically produced foods and the likelihood of farmers adopting organic farming practices. This result aligns with existing literature highlighting the role of economic incentives, such as price premiums, in driving cleaner production (Porumb et al. 2020). In the broader context of expansion of sustainable production methods, this result underscores the importance of financial incentives in influencing decisions to extend the area of land under organic farming. Organic producers who receive premiums for their green products experience increased income potential, which serves as a strong motivation for them to shift away from conventional practices (Digal and Placencia, 2019). This finding also echoes the idea that economic benefits, such as higher market prices for organic produce, act as catalysts for extensifying sustainable and environmentally friendly farming methods (Ume 2023).

Moreover, the positive relationship between premium receipt and organic farming extensification suggests a demand for organic products in the market, encouraging farmers to meet this demand by adopting organic practices. This aligns with the notion that market forces and consumer preferences are pivotal in shaping agricultural practices (Pimentel et al. 2005). In line with our first hypothesis, the result underscores the significance of economic incentives, specifically price premiums, in promoting the extensification of organic farming practices among smallholder farmers in the study area. This finding resonates with existing agricultural literature.The results further provide valuable insights into the relationship between Branding and informal certification and the likelihood of farmers adopting organic farming practices. This finding is noteworthy and can be contextualized within the broader framework of marketing strategies for sustainable production. Firstly, the positive and statistically significant association between branding and informal certification and the extensification of organic farming is in harmony with the notion that proficient marketing and presentation of organic products are pivotal in enticing farmers toward organic agriculture (Bui and Nguyen 2021). Farmers who utilize branding and informal certification tend to highlight organic produce's distinctive qualities and advantages, rendering it more attractive to consumers and fellow farmers. This finding underscores the importance of communication and marketing strategies in promoting sustainable agricultural practices. Secondly, the 40% increase in the likelihood of adopting organic farming for farmers employing Branding and informal certification suggests that these strategies create a sense of trust and credibility among consumers. Trust is a critical factor in consumer decisions to purchase organic products (Saravia-Matus, Rodríguez, and Saravia, et al. 2020). When farmers engage in Branding and informal certification, they signal to consumers that their products meet specific organic standards and are produced in an environmentally friendly and ethical manner. This trust-building aspect can drive consumer demand for organic products, incentivizing more farmers to increase organic farming production. The result emphasizes the role of branding and informal certification as effective strategies for increasing the extensification of organic farming among smallholder farmers. These strategies not only enhance the marketability of organic products but also contribute to building consumer trust in the authenticity of organic produce.

The integration effect between premium pricing and branding suggests that producers who not only charge premium prices for their products but also invest in branding dedicate more of their land to organic farming practices when compared to those who only do one of these actions or neither. In simpler terms, when producers command higher prices for their products and actively promote their brand, they are more likely to benefit from organic farming than those who don't follow this combined approach. This finding suggests that there could be a powerful synergy when producers employ both premium pricing and branding. This synergy seems to motivate them to expand organic farming, potentially because consumers increasingly seek environmentally friendly and high-quality products associated with a recognizable brand. The finding implies that the joint strategy of premium pricing and branding appears to be more effective at encouraging producers to invest more in organic farming compared to using either strategy alone. This finding implies that there may be synergistic benefits

when producers both charge higher prices for their products (premium pricing) and invest in creating a strong brand identity for their goods. This combination could motivate them to expand organic farming, possibly due to increased consumer demand for environmentally friendly and high-quality products associated with a well-known brand.

The finding that farmers receiving government subsidies are less inclined to extensifying their organic farming introduces an intriguing perspective on the influence of subsidies on agricultural practices, particularly within the organic agriculture context. Government subsidies possess the potential to play a pivotal role in bolstering the extensification of organic farming. While the study has unveiled a negative correlation between subsidies and the extensification of organic agriculture, it's crucial to scrutinize the nature of these subsidies. If government policies were restructured to provide incentives exclusively to organic agriculture, such as subsidies tailored for organic inputs or certification expenses, this strategic shift could catalyze a more widespread extensification among farmers. These subsidies could render organic agriculture a more economically feasible choice for smallholder farmers by alleviating some of the initial financial burdens associated with organic farming.

Firstly, the negative relationship between government subsidies and organic farming extensification aligns with previous research suggesting that subsidies often favor conventional farming practices (Falconer et al. 2001). Government subsidies in many countries have historically been directed toward conventional agriculture, including providing fertilizers and improved seeds. These subsidies are intended to increase crop yields and ensure food security. However, they may inadvertently discourage farmers from exploring more sustainable and environmentally friendly practices, such as organic farming. Secondly, the finding raises questions about the alignment of government policies with sustainability goals. Organic farming is often associated with reduced environmental impact, enhanced soil health, and improved biodiversity (Reganold et al. 2021). In contrast, some conventional farming practices supported by subsidies may involve the heavy use of synthetic chemicals and fertilizers, which can have negative environmental consequences. This misalignment between subsidies and sustainability objectives suggests a need for policy adjustments to incentivize and support organic farming. The result underscores the importance of examining the impact of government subsidies on agricultural practices, particularly in the context of sustainable and organic growers. Policymakers may need to reconsider the distribution of subsidies to ensure that they encourage practices that align with environmental and sustainability goals. Most farmers have to pay more to acquire organic fertilizers than conventional farmers who sometimes have access to subsidized inorganic fertilizers. Therefore, subsidies for organic producers is significant in offsetting the additional costs incurred in production.

Conclusion

This study shed light on critical factors influencing the extensification of organic farming among producers in the global south context. We have explored the roles of price premiums, Branding, informal certification, and government subsidies in shaping farmers' decisions to embrace organic practices. Firstly, our results demonstrated that offering price premiums for organically produced foods significantly increases the likelihood of farmers adopting organic farming. This finding underscores the economic incentive provided by premium prices, which can enhance the financial viability of organic farming and encourage its extensification among smallholders. Secondly, branding and informal certification were found to impact the extensification of organic farming positively. Farmers who engaged in Branding and communicated the benefits of organic food to consumers exhibited a higher propensity to adopt organic practices. This result emphasizes the importance of marketing strategies and consumer awareness in promoting organic farming. Thirdly, producers who combine premium pricing and branding are more likely to invest more in organic farming compared to those who don't. This suggests a positive correlation between the two strategies, indicating that the synergy of higher prices and effective branding encourages organic farming extensification. It implies that the joint use of premium pricing and branding is more effective than either strategy on its own in promoting

organic farming among producers. Lastly, our study revealed that government subsidies had a negative association with organic farming extensification. Farmers who received subsidies were less likely to extensify organic practices. This finding raises questions about aligning agricultural policies with sustainability goals and highlights the need for policy adjustments to incentivize organic farming. Our research delivers valuable insights into the intricate dynamics of extensifying organic farming practices. It underscores the pivotal role played by economic incentives, marketing strategies, and policy support in facilitating the shift towards organic agriculture among smallholder farmers.

The findings of this study hold significant implications for the development of policies that foster sustainable and environmentally responsible agricultural practices in Nigeria and other similar developing economies. Policymakers should adopt a comprehensive approach to promote a more inclusive and resilient green economy. One of the primary areas requiring attention is the reassessment of existing subsidy programs. The research highlights that the current focus on subsidizing inorganic fertilizers may not align with promoting organic farming. Policymakers should consider redirecting these subsidies toward organic alternatives. By investing in organic fertilizers and inputs, the government can substantially alleviate the financial burden on farmers extending organic methods. This financial support would enhance the economic feasibility of organic farming, leading to increased extensification of sustainable agricultural practices.

In light of the prevalence of informal certification practices among smallholder farmers in the study area, it is crucial to understand and support these existing mechanisms to facilitate their integration into global markets. While our study does not directly address formal certification schemes, future research and policy development should consider the potential role of formal certification in complementing and strengthening existing informal practices. This may include exploring opportunities to formalize and register informal certification initiatives with relevant authorities, while ensuring that such processes remain farmer-centric and accessible to small-scale agricultural producers. By recognizing the significance of both informal and formal certification mechanisms, policymakers can better support the transition to organic agriculture and enhance smallholders' expansion of organic farming practices.

Additionally, the government can play a crucial role in providing supervision, monitoring, and quality control for these certification processes. This government oversight can help build trust among consumers and international markets, ultimately boosting the export potential of organic products from these regions. Flexibility in certification to accommodate indigenous knowledge and sustainable farming practices is essential to ensure that certification does not become overly burdensome for smallholder farmers.

In essence, these policy initiatives can serve as catalysts for the growth of organic farming in Nigeria and similar contexts. They have the potential to empower small-scale farmers, reduce the environmental impact of agriculture, and align farming practices with sustainable and green economy objectives. Moreover, these measures can improve rural communities' livelihoods and enhance food security while promoting environmentally responsible agriculture.

Appendix 1

Table 6 Probit regression estimates

	First stage (t-values)		
	Premium on organic produce	Farmer group or cooperative society	Branding/informal certification Other variables
Access to the market	2.87***	3.12***	7.82***
Access to organic farming training programs	2.77*	2.13**	6.71***
Distance to government agricultural offices	2.01*	3.19**	7.11***
Other variables			
Market orientation	0.23	0.45	3.23**
Knowledge about organic farming	3.21**	6.32***	6.34**
Production diversity	6.87***	1.67	0.78
Distance to selling point	2.12*	6.45	1.23
Market information	5.78**	8.64***	7.15***
Road type	5.65**	2.18*	9.76***
Mixed farming	21.01***	1.22	5.02**
Gender	12.67***	7.78**	1.26
Age of the respondents	9.01	7.35**	0.24
Education status	8.01	1.23	1.27
Marital Status	0.12	1.39	2.10*
Family size	0.87	0.12	6.12***
Farm size	2.17*	2.11*	1.21
Land ownership	2.98*	0.81	1.27
Tropical Livestock Unit	1.90	0.91	1.23
Off-farm income	1.77	0.72	2.17*
No. of relatives	1.82	2.01*	1.72*
Access to credit	1.04	2.01*	2.35**
Extension visits	2.98*	0.37	0.12
Confidence in extension service	1.27	1.10	0.71
State fixed effect	1.67	2.76*	1.53
Number of obs	415		
Wald chi2	63.56		
Prob > chi^2	0.001		

Stars indicate significance levels at 10%(*), 5%(**) and 1%(***).

Appendix 2

Table 7 Effects on organic farming extensification

	level of organic farming		
	coefficients	Std. Error	t–values
Variables of interest			
Premium on organic produce	0.53	0.0049	2.25**
Branding and informal certification	0.401	0.7421	3.13**
Government subsidies	-0.65	0.0040	-3.01**
Premium*Branding	0.76	0.0031	7.09***
Other variables			
Market orientation	0.66	0.03	3.32**
Knowledge about organic farming	0.11	0.02	0.34
Production diversity	-0.10	0.50	1.08
Distance to selling point	-0.71	0.25	-2.11**
Market information	0.054	0.12	0.01
Road type	-0.36	0.002	-2.23*
Mixed farming	0.87	1.02	1.12
Gender	0.36	0.56	0.01
Age of the respondents	-056	0.12	-0.12
Education status	-0.65	0.29	-0.11
Marital Status	-0.18	0.11	-0.01
Family size	0.11	0.09	1.02
Farm size	0.07	1.04	1.11
Land ownership	0.53	0.02	2.57**
Tropical Livestock Unit	0.59	0.05	1.95*
Off-farm income	0.31	0.21	2.11*
No. of relatives	0.21	0.08	0.12
Access to credit	0.01	1.23	2.71**
Extension visits	0.85	0.08	2.21**
Confidence in extension service	0.89	0.56	2.02*
State fixed effect	0.24	0.28	0.87
/lns1	0.546***		
/lns2	0.671***		
/lns3	-0.414***		
sigma_1	0.214		
sigma_2	0.332		
sigma_3	0.232		
rho_2	-0.5424		
rho_2	-0.1145		
rho_3	-0.2110		

Stars indicate significance levels at 10%(*), 5%(**) and 1%(***).

Author contributions First author was in charge of Conceptualization, Methodology, Formal analysis and investigation, and Writing. The second author was responsible of conceptualization and Supervision.

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Data availability The datasets generated during and/or analyzed during the current study are available in the figshare repository, https://figshare.com/s/58deb8200b1c75cc6543; https://doi.org/10.6084/m9.figshare.20681653.

Declarations

Ethics approval This study recived full ethical approval from the center for agroecology research unit, Nigeria. We also grateful for the center for making this data available.

Competing interests The authors declare no competing interests.

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