CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Impact of Agricultural Cooperatives on Maize Farmers' Technical Efficiency in Nigeria

MASTER'S THESIS

Prague 2023

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Declaration

I hereby declare that I have done this thesis entitled **Impact of agricultural cooperatives on maize farmers' technical efficiency in Nigeria** independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 20/03/2023

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Adedokun Adeolu Stephen

Acknowledgements

I would like to thank God for the grace he gave me to finish this programme successfully. I would also like to appreciate the Czech University of life sciences for the opportunity to study.

Also, I will like to thank my supervisor Ing. Jiří Hejkrlík, PhD for creating enough time to guide me and make me a better research student, his constructive criticism and relentlessness towards bringing the best in me.

I would like to also express my profound gratitude to the Internal Grant Agency of the Faculty of Tropical Agrisciences for providing financial support for the research.

Abstract

In Nigeria, agriculture is a crucial sector that faces several constraints that limit the productivity of farmers. Agricultural cooperatives have emerged as a means of enhancing the well-being of farmers through the provision of inputs, access to resources and information, and improved agricultural practices. These organizations have also the potential to contribute to the technical efficiency of farmers. Therefore, the present study aimed to examine the impact of agricultural cooperatives on the technical efficiency of maize farmers in Nigeria. Specifically, the study aimed to estimate the technical efficiency of maize production among cooperative farmers and compare it with that of non-members, analyse the factors that affect technical efficiency in maize production in cooperatives, and describe the influence of cooperatives in enhancing the technical efficiency of farmers.

The study was carried out in Oyo state, located in the southwestern part of Nigeria. A total of 299 farmers, consisting of 157 cooperative members and 142 non-members, were sampled using a multistage sampling method. A structured questionnaire was used to gather information on the socio-economic characteristics, production, cooperative, and agro-ecological factors. The Cobb-Douglas stochastic production frontier was employed to estimate the technical efficiency scores and identify the factors affecting the technical efficiency of both member and non-member farmers. The study controlled for observable biases by matching the members and non-members before estimating the technical efficiency.

The results revealed that the mean technical efficiency scores of non-members were significantly higher than those of members. Both gender and household size were significant variables affecting the technical efficiency of both member and non-member

farmers. It was found that farmers primarily join agricultural cooperatives to access agricultural loans, which often made them inactive after obtaining the loans. Moreover, non-members also had access to some of the information passed to the cooperatives, and the cooperatives diversified into off-farm enterprises. The study recommends that the state government authorities responsible for granting agricultural cooperative licenses ensure that these groups understand the concept of cooperatives by providing further training on cooperative practices.

Key words: Productivity, collective action, farmer's group, stochastic production frontier, smallholder farmers

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List of the abbreviations used in the thesis

Agricultural Development programs:	ADP
Data Envelopment Analysis:	DEA
Food and Agricultural Organization of the United Nations:	FAO
Global Positioning System:	GPS
Green Revolution Program:	GRP
Gross domestic product:	GDP
International Institute of Tropical Agriculture:	IITA
Likelihood Ratio:	LR
National Accelerated Food Production Program:	NAFPP
National Population Commission:	NPC
Operation Feed the Nation:	OFN
Ordinary Least Square:	OLS
Propensity Score Matching:	PSM
Stochastic Production Frontier:	SPF
Sub-Saharan Africa:	SSA
Sustainable Agricultural Practices:	SAPs
The International Cooperative Alliance:	ICA

1. Introduction and Literature Review

1.1. Introduction

Agricultural cooperatives have been recognized as a crucial tool in promoting the development of smallholder farmers in many countries, including Nigeria. Agriculture is a significant sector of the Nigerian economy, contributing about 23% of the country's GDP in 2021 (FAO, 2021). Maize is an important staple crop in Nigeria, with an estimated production of 10.5 million tons in 2020 (FAO 2021). However, smallholder maize farmers face numerous constraints that limit their productivity, such as a lack of access to markets, credit, and information. One potential solution to these challenges is the formation of agricultural cooperatives.

Agricultural cooperatives are formal organizations owned and managed by farmers who come together to achieve common goals such as accessing markets, credit, and inputs (Zheng et al. 2012). They are aimed at improving the bargaining power of smallholder farmers, reducing transaction costs, and increasing access to extension services and markets (Abate et al. 2014). Cooperatives have been identified as a key strategy for improving the productivity and livelihoods of smallholder farmers and have been promoted as a policy initiative to help them cope with multiple production and marketing challenges

Studies have shown that agricultural cooperatives can have a positive impact on the technical efficiency of smallholder farmers in various parts of the world. For example, a study by Olagunju et al. (2021) in Nigeria found that participation in agricultural cooperatives significantly improves the technical efficiency of smallholder maize

farmers. Similarly, a study by Deng et al. (2021) in China found that participation in cooperatives increases the technical efficiency of smallholder apple farmers.

Despite the potential benefits of agricultural cooperatives, their effectiveness in promoting the development of smallholder farmers in Nigeria is hindered by several challenges. Weak governance structures, limited access to finance, inadequate training, and inadequate support from government and development partners are some of the challenges that hinder the effectiveness of agricultural cooperatives in Nigeria (Kolade & Harpham 2014). Therefore, understanding the impact of agricultural cooperatives on the technical efficiency of maize farmers in Nigeria is essential.

One of the significant challenges faced by smallholder farmers in Nigeria is limited access to credit. Agricultural cooperatives can play an important role in addressing this challenge through providing access to credit facilities. These cooperatives can pool resources and access credit from financial institutions, which can be made available to smallholder farmers at a reasonable interest rate. This will help smallholder farmers to purchase inputs, invest in their farms, and expand their production capacity.

Inadequate training is another significant challenge faced by smallholder farmers in Nigeria. Agricultural cooperatives can address this challenge by providing training and extension services to their members. Through these services, smallholder farmers can learn about new agricultural techniques, crop management practices, and market trends. This will help improve their productivity, increase their income, and enhance their livelihoods.

Government and development partners can also play a crucial role in supporting agricultural cooperatives. They can provide policy and regulatory frameworks that support the formation and operation of agricultural cooperatives. Furthermore, they can

provide financial and technical support to these cooperatives to enhance their effectiveness in promoting the development of smallholder farmers.

1.2. Literature Review

1.2.1. Agriculture in Nigeria

The beginning of the independence of Nigeria and many other African countries in the 1960s were on the basis of self-reliance as a dependent factor on agriculture as a way of livelihood and generation of income for the countries and individuals. At this time, Africa was self-sufficient and reliable for other countries who depended on African countries for agricultural produce. African countries were also significant distributors and leading exporters of agricultural products globally (Adesina 2017) Contrary to this is the Asian countries who battle with food crisis aiming at getting a sustaining program to mitigate this problem. However, by the mid-1960s, there was a green revolution program which increased food production and ensured self-sustainability with a contribution of about 50 million metric tonnes of grain to the world food supply each year. Although Asia still nurses some problems of household food supply as they have not also reached the prime of food security, at the moment, they still do not share from the food burnt sufferings as much as African countries do (Byerlee et al. 2007).

This comparison between the two continents indicates that Africa's food balance sheet has grown from positive to negative while that of Asian countries has increased from negative to positive. More specifically, the growth of food production, for example, grew by 1.5 percent between 2010 and 2015, and the population between the same year 2010 and 2015 increased by 3.5 percent. This is not meeting up to the demand of the people and has led to a decline in per capita food consumption and, in turn, in sub-Saharan

African countries with a less average calorific intake. This problem is now beyond the growing population to stagnation in food production and increasing degradation of natural resources. However, the population level is also growing and likely to reach 2.4 billion by 2025, further increasing the demand for food (Olomola 2017) The problem is not any less, and as such, African food security demands attention from decision-makers and policy formulations to harness the level of poverty and, at the same time, ensure food security. These two seem achievable only by making favourable policies to increase agricultural growth to manage the growing population in terms of demand for food and generate income for survival.

Similarly, there should be a higher level of technical changes with an increase in the population of farmhands that will make a remarkable yield (Kurukulasuriya & Rosenthal 2003). Of course, the revolution of maize production will also need to put in place rural infrastructures, policy changes, and institutional changes. Maize as a form of grain is equally as important to Africa as rice is in Asia. It is a staple crop in Eastern and Southern Africa and was introduced into Africa by Portuguese traders. It was gradually moved in by the traders and slowly consumed till generally accepted because of its diverse processed forms and easy storage (Olayide et al. 2016).

Nigeria's agricultural sector constitutes four different sub-sectors just like many other African countries: crop production, livestock, forestry, and fishery (Olomola 2017). Agriculture contributes significantly to economic development as over 70 percent of the population generates revenue from production, processing, or marketing. Similarly, agriculture also employs about 35 percent of the people in 2021.

The Nigerian agricultural sector is coordinated by the Ministry of Agriculture and Rural Development under the control of the government. This ministry alone manages about 50 different departments or agencies targeted towards agricultural development.

Other challenges could not be well addressed due to little hands-on deck. The limited capacity of the ministry also made solving agricultural challenges more tedious, such as land allocation and accessibility, different pricing, and market systems (Akinyele 2009; Olomola 2017). These challenges affect most farmers and limit how much they can contribute to society in economic development. In line with this, the crop farmers contribute the highest value in agriculture among other sectors as it accounts for about 87 percent of agricultural sector output, which is significantly the highest sector (Oyaniran Taiwo 2020). The crop production includes several crops such as maize, cassava, watermelon, guinea corn, and yam.

Several programs and policies are set to transform and maintain the Nigerian agricultural sector to maximize its contributions towards economic development through agriculture. Some of the programs had lapsed, but they at least made a remarkable impact to the societal growth, and some of them include; Agricultural Development programs (ADP), Operation Feed the Nation (OFN), Green Revolution Program (GRP), National Accelerated Food Production Program (NAFPP) and many others (FAO 2021)

1.2.2. **Maize Farming in Nigeria**

Maize farming is the cultivation of corn (maize) which belongs to the family of grasses (Gramineae), and it is scientifically called Zea mays. This crop can be cultivated on all farm soils in Nigeria. Still, it specifically records high yield in a well-drained fertile loamy soil and thrives well in several climatic conditions (IITA 2014). This rain-fed crop requires less capital and sprouts fast within a short germination period. It is also a crop used to determine the crop pattern of so many subsistence farmers. Its consumption is not only for humans but also as animal feeds and as raw materials for different industrial sectors (Kutka 2011). Other than this, maize is also easy to produce and has a high yield

compared to the seeds planted, and it is versatile, which is a factor to why it is grown in several places across Nigeria (IITA 2014). In addition, regarding food nutrients, maize has a high level of energy given food at the mature stage and a high level of vitamins it eaten at the immature stage.

This grain crop has several dynamic uses because of its form of processing. It can be consumed in different forms ranging from boiling, roasting, or even frying. It can also be converted through different industrial uses into cornflakes, beer and beverages, golden morn, custard, and many others (Onuk et al. 2010). With these diverse forms, there is hardly a chance for anyone not to consume either maize or maize products.

Improving maize production is one of the most crucial strategies for food security in developing countries (Nasseer et al. 2021). This can be ensured by bringing maize technologies to meet the human and animal demands for the maize through several technologies, including maize hybridization. With agricultural sustainability, maize hybridization will contribute to the integrated pest management system through maize cultivars.

Maize production is susceptible to soil-related issues that can affect its yield and quality, such as nutrient deficiencies, organic matter depletion, and soil acidity. Nitrogen, phosphorus, and potassium deficiencies can result in stunted growth and poor-quality grain. Organic matter depletion can reduce soil fertility, and continuous maize cultivation without sufficient organic matter can lead to soil degradation. Soil acidity can also reduce nutrient availability, especially of essential nutrients like phosphorus, calcium, and magnesium. Farmers can address these issues by soil testing, applying adequate fertilizers and organic amendments such as compost or manure, and using lime or other soil amendments to improve soil pH levels (FAO 2013).

Maize farming is ranked among the first three crop farming in Nigeria, and it is ranked the first in southeast Nigeria and most important across other regions in Nigeria. Maize has shown to possess high economic importance in Nigeria. The diverse use also results in high demand for the crop regardless of economic class. There is a need for higher productivity and sustainability plans to ensure that the demand is met (Bruinsma 2017). Although it is projected that land expansion can contribute to maize productivity, it will similarly lead to poor diversity as most of the farmers will consume the expanded lands on arable crops such as maize and then affect crop (IITA 2014) even in a limited number of years.

To ensure food security, there are several measures put in place by the government and several farm organizations having identified maize and its considerable importance among other crops. The idea was also attached to using maize for poverty reduction and food security by many African countries, including Nigeria (Ogunniyi et al. 2021). This has been proven to be accurate as compared with other crops, especially with another important crop like cassava, which is why it is sometimes referred to as the golden seed. Maize has a shorter production period and meets up with the hunger needs of Nigerians first before many other food crops. So also, maize can be consumed in many forms or conversion rates than cassava. Also, in comparison to rice, maize survives in so many soil ranges, and with the use of the mechanical and technological improvised system, maize has a yield of about 11 tonnes per hectare and with the usual traditional form has about 2 tonnes per hectare which is relatively low but still not bad compared to other crops in terms of the cost of production (IITA 2014).

1.2.2.1. Technical Efficiency of Maize Production

The importance of maize production cannot be overemphasized, as it contributes a significant percentage to ensuring food production in Nigeria. In a report by FAO (2020), Nigeria produced about 12 million tonnes of maize which constituted about 1.03% of the worlds production of maize. Maize cultivation covers about 561,397,290 ha (61% total cultivable land in Nigeria) and about 98% of these maize farmers are involved in rain fed agriculture (FAO 2020).

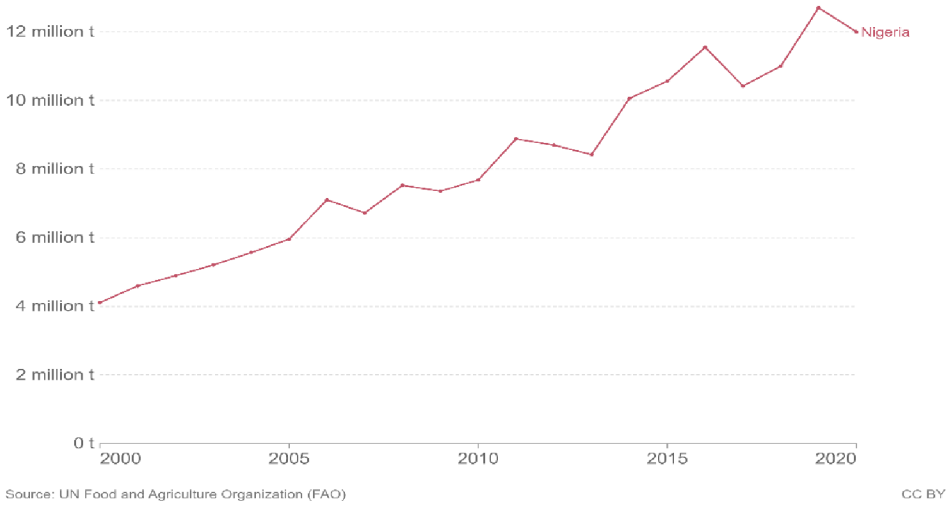

Figure 1. Trend of maize production in Nigeria from 2000-2020

Recently, there has been a higher demand for maize than the quantity of maize supplied as a result of increase in population leading to fluctuation in maize production. Factors such as farm management practices, land tenure, technical know-how, resource use among others are responsible for low productivity of maize. Also, maize production is affected by development of advanced technologies, since developing countries have difficulty in getting access to hybrid seeds, pesticides, herbicides, fertilizer and better management practices. Due to the low knowledge about optimum level of farm resources

and effective use of such resources. The managerial resources are not efficiently allocated, leading to decrease in productivity of maize (Idris et al. 2015).

1.2.2.2. Maize and Sustainable Agricultural Practices

Despite the potential of maize in enhancing food security and eradicating poverty in Africa, problems associated with farming such as low soil fertility, environmental issues can hinder this from happening. By enhancing soil fertility, storing carbon for the purpose of reducing climate change, and boosting crop yields and incomes, sustainable agricultural practices (SAPs) provide a potential solution to some of these issues. SAPs, broadly construed, may consist of intercropping or crop rotation with legumes, residue retention, conservation tillage, better crop varieties, utilizing stone and soil bunds in addition to organic fertilizers will help conserve water and soil. (Julius Manda, 2016). The use of sustainable agricultural practices is widely acknowledged as a practical way to boost agricultural output with no environmental harm (Oumer et al. 2020). Also, evidence from empirical research in Sub-Saharan Africa (SSA) suggests that SAP techniques can assist smallholder farmers by boosting farm incomes and ecosystem services as well as crop yields (Falco & Veronesi 2013; Arslan et al. 2015; Wossen et al. 2017; Oumer et al. 2020)

1.2.3. Concept of Cooperatives

Cooperative are community-based, self-controlled, funded, and organized financial institutions intended to take care of and harness the wellbeing of all its members. A significant instrument for expanding smallholder producers' access to markets is generally acknowledged to be agricultural cooperatives. Cooperatives provide smallholders the chance to take collective action to enter markets that might otherwise be

unavailable, pool resources to get around financial obstacles, improve communication flows, and jointly bargain with buyers to get better pricing (Poole 2010). A growing body of research shows that agricultural cooperatives help smallholders in developing nations adopt better agricultural technologies and perform better economically (Ma et al. 2018; Neupane et al. 2022). Agricultural marketing cooperatives have been the most widely used traditional form of cooperative development that has connected developing nations with the rest of the world through export commodity trade.

1.2.4. Factors Influencing the Participation of Members of Agricultural Cooperatives

Understanding the factors that influence membership in agricultural cooperatives is crucial for sustainability and growth of these organizations, therefore, identifying the factors that influence membership can help cooperatives to design effective strategies for attracting and retaining members and enhancing their overall performance. According to Arayesh & Mammi (2010), factors affect the involvement of the members of Agricultural cooperative societies, which could be demographic factors or socioeconomic characteristics. This research found out that there is a significant and positive relationship between the socioeconomic characteristics such as higher age and education and the participation of members in the cooperatives.

Similar research conducted on cooperative society on women's participation in cooperative society in Yeba, Ogun state, Nigeria by Olawale & Awotide (2012) also concluded a significant relationship between age, forms of cooperative, years of business experience and participation of women in the cooperative societies. Each of the variables (age, years of business experience, forms of cooperative) are 10 percent statistically significant to the participation and a positive relationship, which makes them directly

impact the participation of women in a cooperative society. In addition, Ajayi & Muhammed (2014), researched that larger household sizes also have a positive relationship with participation in a cooperative society. This is because they tend to have more financial responsibilities to contend with and, as such, need more assistance from the group compared to others. The level of education also has a positive relationship with participation in a cooperative society. It was measured by the number of years spent in schools as it seems the more educated the people are, the higher the chances of participating in cooperative societies.

In a study carried out by Awotide et al (2015) in Nigeria, it was concluded that age, gender, education and farm size are significant factors affecting farmers participation in cooperative. The findings indicated that younger farmers are more likely than older farmers to join in cooperatives. Also, male farmers are more likely to participate in cooperative that the female. In the same vein, farmers with higher former education are less likely to participate in cooperative while farmers with small size are more likely to join cooperative organizations than their counterparts. In another research by Zakari & Seydou (2021), carried out in Niger, the findings indicated that factors such as the size of the household, the number of livestock, the size of the farm, contact with extension services, the presence of irrigated land, and market access have a positive and significant impact on a farmer's decision to join a group.

1.2.5. Technical Efficiency

Efficiency is possible only when the producer maintains the use of the existing technological resources and still produces the maximum output level from the inputs used (Amadou 2007). This can be achieved in two forms. It could be by minimizing the use of resources required to produce a particular quantity of output, or it could also be by

maximizing the output derived from a set of resources. The production aspect of economics is detailed to a high level as it puts in place both the technical and allocative efficiencies. Technical efficiency is concerned with the barrier challenging the farmer and his ability to maximize the output given the resource constraints. On the other hand, the allocative efficiency of the farmer is also his ability to maximize the use of the available resources given the alternating prices and production functions (Battese 1997) A firm can be economically efficient production-wise if it is technically efficient.

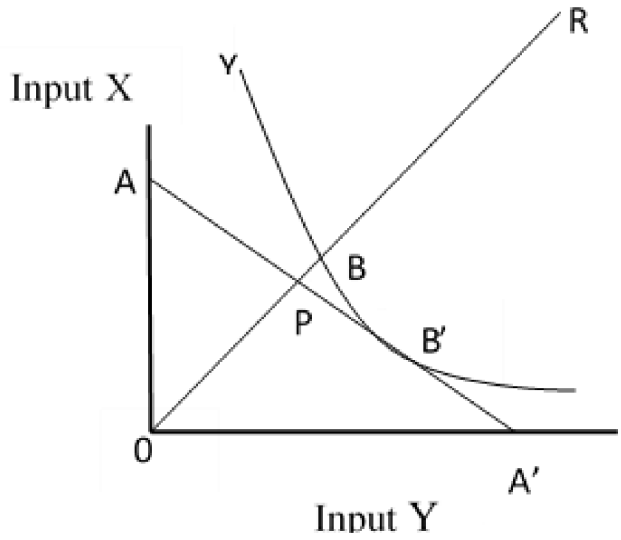

Figure 2. Production possibility curve showing technical efficiency

The production possibility curve indicates on the frontier that any farmer that operates on the curve is operating efficiently, and any production below is inefficient (Rahman & Umar H S 2009). However, it is not possible to produce above the production functions as there are no resources to meet up with producing above the function. This concept is related to every other efficiency theory as the concern of the production is to meet up with the lowest point of the curve on the short-run average cost curve. Therefore, production efficiency cannot be complete without considering technical and allocative efficiencies. Similarly, technical efficiency is also crucial for allocative efficiency, which

implies a particular output level, which can be derived by price equating to the marginal cost of production.

1.2.5.1. Approaches for measuring technical efficiencies

There are several approaches to measuring the technical efficiency of crop production, but more specifically, there are two, and they are:

- Parametric
- Non-parametric methods.

1.2.5.1.1 Non-parametric Approach

The aim to measure the productive efficiency using the non-parametric approach involves using Data Envelopment Analysis by considering multiple inputs and outputs (Tolga et al. 2009). Within the use of the DEA approach, there are two other significant orientations which are:

- Input orientation
- Output orientation

The approach has some challenges in many ways, such as the recommendation for reducing input and, other times, the expansion of the output levels, which are also fixed proportions. The non-parametric DEA approach, which assumes no stochastic errors and is consequently sensitive to outliers, attributes deviations from the production frontier to inefficiency. This limits its application to agricultural research since production is regularly impacted by unpredictably weather conditions.

1.2.5.1.2 Parametric Approach

This approach is another perspective from the angle or stochastic approach, and it shows the relationship between the output and input levels using two error terms. Among the two error terms, one is the standard error which has a mean of zero with a constant variance. In contrast, the second error constitutes technical inefficiency and may be written in the form of a half-normal, truncated normal, exponential, or two-parameter gamma distribution (Njeru 2010).

Technical efficiency of production, in this case, is now estimated through the maximum likelihood of the production function subject to the error terms stated above. This production possibility function employs several methods and procedures. The production function is typically used to determine the technical efficiency indicators. The ordinary least square (OLS) approach is then used to regress the variable indicators against independent variables, which describe the characteristics of the farm. This phase has certain drawbacks, but the biggest one is the assumption that inefficiency impacts are independent..

1.2.6. Factors Affecting Technical Efficiency

Factors affecting technical efficiency have been looked into by different authors; with different explanation to the categories which these factors can be divided into. Firstly Passel et al. (2014) categorized these factors into structural and agent factors, where agent factors include age, social capital and education; and structural factors further categorized into off farm (policy, infrastructure etc.) and on farm factors (farm size, soil fertility, irrigation, drainage etc.)

According to Brázdik (2006) these factors were also categorized into three groups;

- Farm-specific variables: these are inputs that are not fixed and change with the production level; they include seeds, chemicals, fertilizer, and labor size. It further includes organizational structures such as tenure crop varieties, among others.
- Economic factors relate to the prices and costs of the varying inputs and outputs. This is very much concerned with money and values.
- Environmental factors

Lastly and the most relevant to this study, factors affecting technical efficiency of a farmer could be also classified into socioeconomic, institutional, farm-level(production) characteristics and environmental factors. These factors are likely to technically affect the maize farmers' efficiency, but they could be negative or positive. Rahman & Umar H S (2009) also conducted research and used stochastic cost frontier to analyse technical efficiency and concluded that education, credit per acre, and the number of extensions visits significantly increased technical efficiency. In addition, according to Mkhabela (2005), a high number of extension services, years of practice, and advantaged cropping systems increase the efficiency level of farmers more experience. He further explained that the increased level of education and off-farm income decreases efficiency due to more educated farmers involved in part-time farming. Although, this is contradictory to the research of Murthy et al. 2009), which states there is a positive relationship between education and efficiency. Just like the age of the farmers, he also concluded there is a positive relationship between the age of farmers is positively related to the technical efficiency even though not sufficient enough. In addition, he found out that institutional factors such as agricultural cooperative societies also affected technical efficiency. Rahman & Umar H S (2009) conducted a study on the technical efficiency of crop production. They realized that

labor, age, fertilizer, household size, gender, marital status, other occupation, and land ownership were essential factors related to technical efficiency.

Most of the studies conducted in African countries on technical efficiency of crops usually explores the environmental factors but hardly concentrate on the institutional factors such as agricultural cooperative society. Furthermore, most studies usually concentrate on a general review of crops and are not specific to a particular crop. This study then narrows down the review into maize production.

1.2.7. Impact of Cooperatives on Technical Efficiency

Cooperative is regarded globally to contribute to the economic development in the society and, as such, is regarded as an integral part of farmers' society. Therefore, it is regarded as a reliable organization contributing about 33 percent of its annual earnings to agriculture and food processing development (ICA 2017). These are the statistics at the global level, and similar value attached to cooperative is the same for African countries, including Nigeria. They have also identified cooperatives as leverage for agriculture to develop and ensure a high level of food security is achieved. This is further achieved by ensuring production and technical efficiency and solving the problems of inadequate capital, inadequate access to loans, and a high level of illiteracy among farmers together as a cooperative organization (Awotide et al. 2015).

Several other research has contributed to cooperatives at different levels of production, including micro; that is, the farmer in relation to the organization and macro; that is, the organization in relation to the nation as a whole. ICA (2017) also found that the impacts of cooperatives are dependent on the regularities and standard of the organization and may also be dependent on the local context and, in another case, could even be about other government initiatives such as policy formulations. The government

interventions and ideas could also record a level of positive relationship with the farmers' technical efficiency in some cases. Deng et al. (2021) argued that the lack of access to cooperatives is high. Also, low support from external agencies contributed to transaction costs, which is against the purpose to which the organization is created. Cooperative societies are supposed to give the edge to the farmers, increase bargaining power, and give a high level of awareness to make the market sales worthwhile (Deng et al. 2021). Therefore, cooperative Societies that sell or markets farm produce on behalf of their members will likely generate more technical efficiency than the others because the price which their products are sold for doesn't take into account the transaction cost which other non-members may encounter, thereby reducing their gross margin or even profit. Also, Cooperative members have access to some specific kind of information which enables efficient production in terms of reducing cost of production and practising more effective practices.

There are several studies that have established the importance of cooperative as a means of solving farmers' problems, such as reducing transaction cost through collective action in developing countries (Ainembabazi et al. 2017). There is also empirical evidence showing that participation of farmers in cooperatives increases farm revenue and economic welfare of farmers through increased yield and technical efficiency (Kumar et al. 2018; Michalek et al. 2018). Their participation in these groups facilitates access to fertilizer, inputs, irrigation facilities, improved seed facilities and other technological innovations (Kolade & Harpham 2014; Wossen et al. 2017). These technological innovations can ensure increase in technical efficiency and yield of farmers through optimal combination and use of inputs (Ma et al. 2018).

Agricultural cooperatives also influence market bargaining power and prices of farm produce. This serves as a motivation for farmers to increase output and technical

efficiency. Cooperative also serve as a channel to obtain relevant information on market price, input sales etc. which ensure that yield is better marketed (Olagunju et al. 2021). There are arguments that participation of farmers in cooperative comes with associated costs incurred by farmers. Poor farmers belong to the poorest group of cooperatives, limiting them to take full advantage of the benefits of cooperatives, because they cannot afford the financial commitments necessary for active involvement (Olagunju et al. 2021)

Researchers' empirical studies also reveal the impact of cooperative society on technical efficiency. According to Abate et al. (2014), using Ethiopian cooperative societies as a case study, shows a positive relationship between the level of production of farm produce and cooperative society members. He reported that cooperative organization members could tend to get more output and efficiency from a given level of input than other non-members of a cooperative society. This is as a result of cooperative members getting benefits such as easy access to productive inputs and support services ranging from information, training and extension on input application. He further concludes that promoting agricultural cooperatives will help members develop and assist their production efficiency and make them regard themselves as fellow extension agents to each other without going too far.

Similarly, Zamani et al. (2019) compared the farms of cooperative society to noncooperative society. They measured the economy of scale between the two. The efficiency score generated from the two indicates a differing scale level as cooperative society tends to have a higher average efficiency score than noncooperative society farms. This research conducted in Iran showed further that a sugar beet cooperative society is substantially better than a noncooperative society because of the support they tend to get from their members in terms of guidance and access to the market at needful times. In addition, Ma et al. (2018) used a different analytical tool (Stochastic production frontier),

intending to consider both the observable and unobservable factors that contribute to the efficiency of cooperative society compared to the noncooperative society. The result showed that the efficiency of cooperative society members is almost 90 percent compared to 70 percent of the non-members of cooperative society. Ma et al. (2018) explanation to this is that cooperatives assist farmer in orchard management, quality control and efficient use of yield enhancing technologies. Ahn et al. (2012), in their comparative studies between the farms under private ownership and cooperative societies, showed similar shortcomings just like above. It further compared different crops of cooperative and private farms, and maize farmers had significant growth as a result of their membership in cooperatives. They then concluded that cooperative farms require fewer individual efforts but more of the group efforts, and it similarly earns more than other noncooperative farms. Qu et al. (2020) work on the effect of agricultural cooperatives on the technical efficiency of apple growers, the cooperatives were split into two groups: the marketing group and the non-marketing group. The findings indicated that cooperative members who did not participate in marketing had greater levels of technical efficiency than non-members. This is explained by the fact that the cooperatives offer marketing and wholesale services, whilst the non-marketing group helps farmers with production, management support, and farming guidance.

Table 1. The list of studies on impact of cooperatives on farmers technical efficiency

Author and Year	Country	Method	Impact
Olagunju et al. (2021)	Nigeria	Propensity score matching procedure, sample selection stochastic production frontier and stochastic meta frontier.	Technical efficiency of members is consistently higher than non- members of cooperatives.
Abate et al. (2014)	Ethiopia	Propensity score matching procedure, stochastic production frontier and Rosenbaum sensitivity analysis	Agricultural cooperatives significantly contribute to members technical efficiency
Deng et al. (2021)	China	Propensity score matching and sample selection-corrected stochastic production frontier.	Farmer professional cooperative help farmers improve technical efficiency.
Ma et al. (2018)	China	Propensity score matching procedure and sample selection stochastic production frontier	Members of cooperative are more efficient than non -members
Ahado et al. (2022)	Mongolia	Propensity score matching procedure, sample selection stochastic production frontier, stochastic meta frontier, and control function approach	Members of cooperative are more efficient than non-members
Qu et al. (2020)	China	Propensity score matching procedure and stochastic production frontier modelling	Member of Cooperatives that were not engaged in marketing achieved higher technical efficiency than non-members.
Adjin & Henning (2020)	Senegal	Propensity score matching procedure, sample selection stochastic production frontier, stochastic meta frontier	Cooperative members do not technically perform better than non- members

2. Aims of the Thesis

In spite of the growth in the interest from policymakers on the importance of agricultural cooperative society in improving technical efficiency in developing countries, there has been a few empirical studies to this effect (Abate et al. 2014; Ma et al. 2018; Olagunju et al. 2021). Several studies have worked on analysing the technical efficiency of maize farmers, but little studies exist for the impact of cooperatives on technical efficiency of maize farmers. Therefore, the **main aim** of this study is to analyse the impact of agricultural cooperative society on maize farmers technical efficiency in Nigeria.

The **specific aims** are:

i. To estimate the technical efficiency of maize production among cooperative farmers in comparison with non-members of cooperatives.

ii. To analyse factors affecting technical efficiency in maize production in the cooperatives.

iii. To describe the influence of cooperative in improving the technical efficiency of farmers.

3. Conceptual Framework and Methodology

3.1. Study area

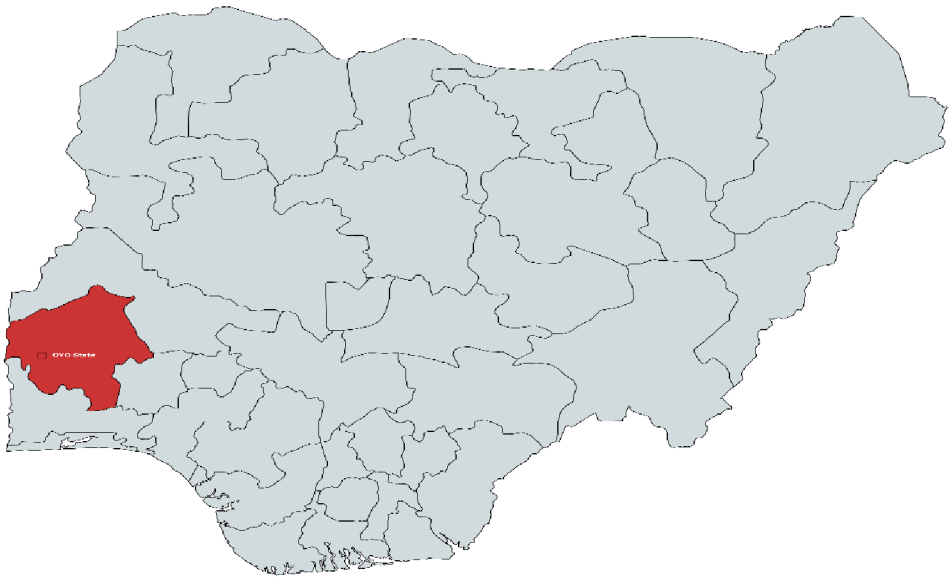

Figure 3. Map of Nigeria, highlighting Oyo state (Source: Author's illustration with Mapchart)

The study was carried out in Oyo States, Southwestern part of Nigeria. Oyo State is one of the thirty-six states of the Federal Republic of Nigeria and Ibadan which is the capital is known to be the largest indigenous city is Africa. Oyo State is located between latitudes 2^0 38^1 and 4^0 35^1 east of the Greenwich meridian. Oyo State covers an area of 28,454 square kilometre [2,845,400 H]. According to National Population Commission (NPC), Oyo state has a population of 5,591,585 people. t is bordered by Ogun State in the south, Kwara State in the north, the Republic of Benin in the west, and Osun State in the east. For the majority of individuals in the State, agriculture is their main source of income. The state is located in the equatorial rainforest belt, and the area gets between

155 and 1800 millimetres of rain annually. The areas have a mean annual temperature of 26.2 degrees Celsius, a distinct rainy season from April to late October, and a dry season from November to March. The humidity is high between July and December and low between December and February. Yam, maize, cassava, millet, plantain, banana, rice, and fishery are some of the food and cash crops that can grow well in a tropical climate.

3.2. Agricultural Cooperatives in Oyo state

Agricultural cooperatives in Oyo state, Nigeria, play a crucial role in the development of the rural sector. Firstly, the age of agricultural cooperatives in Oyo state varies. For instance, the Ibadan Farmers' Cooperative Society, one of the oldest agricultural cooperatives in Oyo state, was established in 1928. These cooperatives provide a range of services to their members, including access to credit, inputs such as seeds and fertilizers, markets for their products, and training and extension services. Some cooperatives also engage in processing and value addition activities.

Agricultural cooperatives in Oyo state receive support from various sources, including the government, international organizations, and private sector organizations. The government provides funding for some cooperatives, and there are also programs to support the development of agricultural cooperatives in Nigeria. Private sector organizations, such as banks and agribusinesses, also provide support to some cooperatives (FAO 2017)

The size of agricultural cooperatives in Oyo state varies greatly. For example, the Iseyin Cooperative Union has over 10,000 members, while some smaller cooperatives may have only a few members (Ogunniyi et al. 2021).

3.3. Sampling Technique

The target population of this research are maize farmers (cooperative members and non-members). A multistage sampling technique was used to select respondents for the study. The first stage was a purposive selection of five local government areas in Oyo state, where maize farmers are more concentrated. The second stage was a selection of two villages each from the five local government areas to make a total of ten villages. The third and final stage was a convenience sampling selection of fifteen farmers that are members of cooperative and another fifteen maize farmers who do not belong to cooperative from each of the selected villages. After removal of outliers, a total of 299 maize farmers; 157 members of cooperative and 142 non-members of cooperatives was selected. In order to avoid spill-over effect, the samples for cooperatives members and non-members were selected from two distinct part of the villages i.e., areas in the villages where non-members do not benefit from the cooperatives they do not belong to and areas dominated by cooperative members, still in the same villages.

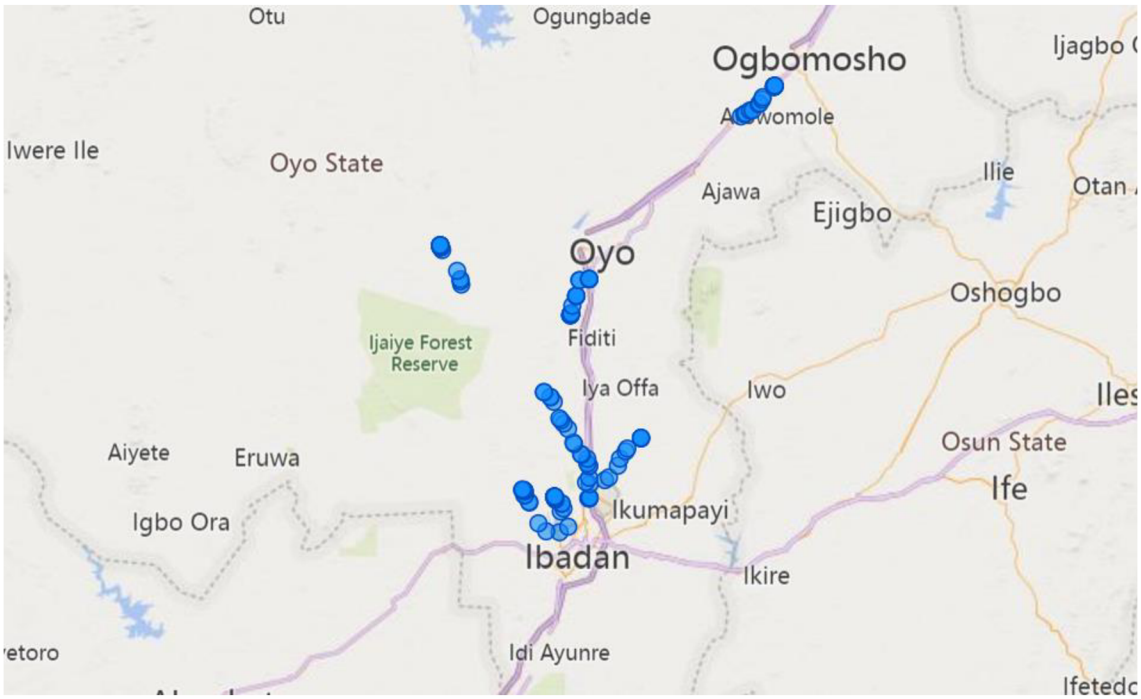

Figure 4. GPS coordinates of surveyed areas (Source: Author's illustration with data from field)

3.4. Data Collection

Data on production and socioeconomic characteristics was collected through face-to-face interviews using a structured questionnaire. The respondents were administered questions using the Nestforms web application, which allowed them to record their GPS coordinates. The questionnaire consisted of three sections: socio-economic and farm information, agricultural cooperative section, and production and agroecological section. The questionnaire contained a total of 50 questions that were structured based on previous research. To enhance the reliability and validity of the collected data, a pilot test was conducted, and multiple questions were formulated to obtain specific data. For instance, output data was collected in both financial value and yield to enable comparisons.

3.5. Conceptual framework

The conceptual framework for this study (Figure 5) shows the relationship between the variables of this study. The maize farmers' socioeconomic characteristics include Age, level of education, gender, household size, experience, credit access. The level of education is measured using the number of years spent in school. The institutional factors suit the exact functions and duties on which the cooperative society was founded, including higher price of produce, access to quality inputs, marketing of produce, reduced cost of production, access to credit, relevant market information, extension services, good agricultural practices. The production factors refer to production inputs such as fertilizer, agrochemicals, and farm machinery. Lastly, the Agro-ecological factors are conditions such as soil quality, pest and disease incidence and water conservation.

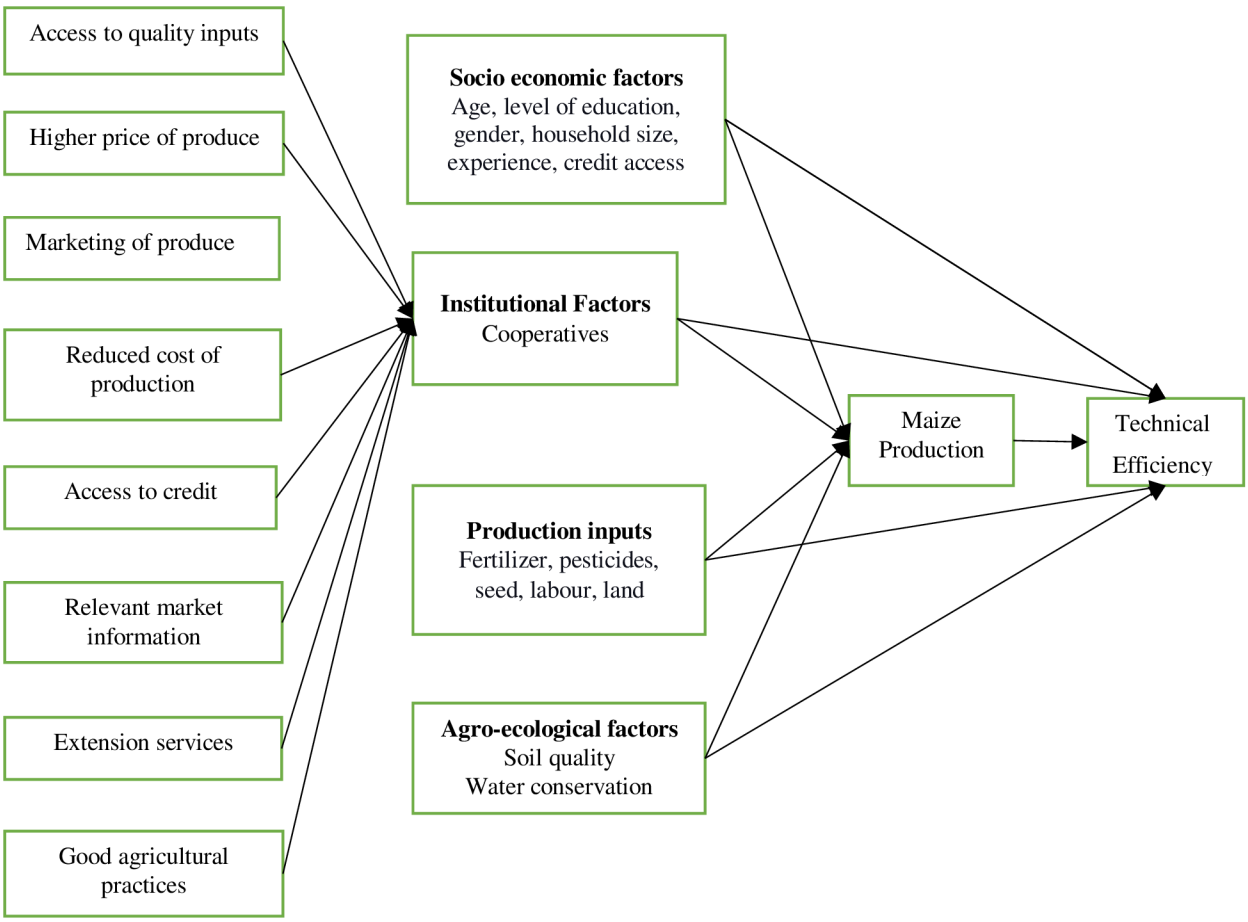

Figure 5. Conceptual framework of research

3.6. Analytical Framework

3.6.1. Technical Efficiency and Stochastic Production Frontier Model

To accomplish the initial goal of evaluating the technical efficiency of farmers and contrasting cooperative members with non-members, the study employed the parametric method of stochastic production frontier analysis. This decision was made because of the limitations associated with the non-parametric DEA approach. On this

basis, in line with Abdul-Rahaman & Abdulai (2018); Ma et al. (2018); Adebayo et al. (2020); Olagunju et al. (2021), SPF is adopted to achieve the objective of this research.

The standard stochastic production frontier model is specified as

$$Y_i = \mathrm{f}(X_i, C_i) + \varepsilon_i \; ; \varepsilon_i = v_i - u_i \qquad (1)$$

Where Y_i is the maize output of the ith farmer, X_i denotes a vector of inputs and other explanatory variables. C_i is a binary variable that captures the impact of cooperative membership (where 1= member, 0 = non- member). ε_i is the error term and v_i is the two-sided error term while u_i denotes the one-sided error term capturing efficiency. It is assumed that v_i and u_i are identically and independently distributed.

There are two functional forms that are mostly employed for analysing efficiency in agricultural production economics, which are Cobb Douglas and Translog. Following González-Flores et al. (2014); Ma et al. (2018); Olagunju et al. (2021) the production frontier was estimated using a Cobb-Douglas specification as follows:

$$\ln(Y_i) = \beta_0 + \sum_{K=1}^{6} \beta_j \ln X_{ji} + \sum_{K=1}^{1} \theta_k \ln D_{ki} + v_i - u_i \text{ , only if } C_i = 1 \qquad (2)$$

where ln denotes natural logarithm,

Y_i is Value of output of ith maize farmer,

X_{ji} represents a set of inputs;

where

X_1= Fertilizer; X_2 = Pestides; X_3= Seed; X_4= Maize farm size; X_5 =Hired labor

X_6=Family labor

D is the binary variable;

where D_1 = Irrigation

And θ_k are the unknown parameters to be estimated;

v_i and u_i indicate the two components of the composed random error.

Following Bravo-Ureta et al. (2012); Ma et al. (2018); Olagunju et al. (2021), the dependent variable in the SPF model is the value of maize output/hectare measured in Nigerian Naira. Unlike previous studies (such as Abdul-Rahaman & Abdulai (2018); Adebayo et al. (2020) that employed yield as a dependent variable, the use of value of maize output per hectare allows adjustment for inherent quality variations in maize output such as grain size, weight and colour and solid content. The independent variables include traditional production inputs and binary variables. It is important to note that not all farmers use some inputs, for example, many farmers may not use hired labour for maize production, therefore the log- transformation process will yield many missing values. To address the zero values of inputs, (Battese 1997) procedure was followed to correct for zero values by including dummies for input variables, in such a way that the logarithm of the inputs with zero value is taken only if it is positive, and zero otherwise (Villano et al. 2015; Abdul-Rahaman & Abdulai 2018; Ma et al. 2018; Olagunju et al. 2021)

In order to achieve the second objective of analysing - the socio-economic factors that affect technical efficiency between the farmer groups, the technical inefficiency effect model was adopted. The technical inefficiency effect u_i is a linear function of socio-economic factors

illustrated below: $u_i = \pi_0 + \sum_{K=1}^{8} \pi_j S_{ji}$ (3)

Where π_j is the coefficient of explanatory variable

S_i denotes socio economic variables;

Where:

S_1= Age of farmer; S_2 =Education of farmer; S_3= Gender of farmer; S_4= Maize farming experience; S_5= Household size; S_6= Credit access; S_7= Extension services

3.6.2. Selection Bias in Stochastic Production Frontier (SPF) Model

The underlying condition that necessitates the estimation of production function is that all farmers have access to the same technology. However, this condition does not hold in this study because farmers decide whether to belong or not belong to a cooperative depending on both observable factors. Therefore, due to self-selection, cooperative members and non-members may be faced with different production frontiers since the variable representing cooperative membership is endogenously determined. In other words, there may be selection bias due to the correlation between the error term in the selection equation and the typical error term in the stochastic production frontier model, which needs to be addressed in order to achieve accurate and consistent parameter estimates related to participation.

3.6.3. Propensity Score Matching

The use of Propensity Score Matching (PSM) will make it possible to match farmers who are members of agricultural cooperatives and those who are not, based in observed characteristics. It was introduced by Rosenbaum and Rubin in 1983, primarily used to compare two groups of subjects but can be applied to analysis of more than two groups. PSM operates based on two fundamental presumptions. The first is conditional independence, which states that observable traits must be independent of possible results and implies that the cooperative's membership decision is solely based on observable traits of farmers. The second requirement is the common support or overlap condition, which states that the distributions of observable features among cooperative members and

non-members must overlap (Jelliffe et al. 2018). To address the potential selectivity effects resulting from observable factors, the PSM technique matches cooperative members and non-members who are comparable in observed features, depending on the PSM scores. Using a binary choice model (such a logit or probit) to estimate propensity scores for all observations in the sample (in this case, members and non-members) is the first step in doing PSM. Based on a vector of observed time-invariant variables, the scores created, which represent the likelihood of being a member of agricultural cooperatives—are then used to match members with non-members.

3.6.4. Cooperative membership

Given the rationality of a farmer in a decision-making process and following previous studies on agricultural cooperatives, a farmer chooses whether or not to join an agricultural cooperative by comparing to know if the expected utility gained from the membership C_M^* is higher than the one from non- membership C_N^*. This implies that a farmer is a member of a cooperative if the expected net utility is greater than zero, that is $C_i^* = C_M^* - C_N^* > 0$. Although the utility difference cannot be observed directly, the decision by farmers to choose cooperative membership can be explained by demographic and social characteristics. This utility gain can be specified as a function of observed covariates in a latent variable model as follows.

$$C_i^* = \propto' z_i + \vartheta_i \text{ , } C_i = 1 \text{ (if } C_i^* > 0) \quad (1)$$

Where C_i is a binary variable that represents cooperative membership status that takes the value of 1 if the farmer is a member and 0 if otherwise. $\propto'$ is a vector of parameters to be estimated; z_i is a vector of exogenous farm and socio-economic factors that can influence cooperative membership decision. ϑ_i represents the random error with $[0,\sigma^2]$ distribution.

3.6.5. Influence of Cooperatives on Technical Efficiency

In order to achieve the third objective of analysing the influence of cooperative on the technical efficiency of member farmers, we make use of descriptive statistics of our quantitative data to analyse the responses from farmers as to why they joined the cooperative and what they are benefitting from the cooperative. A qualitative analysis will also be done based on the response from key respondents in the cooperative leadership.

3.6.6. Description of Variables Used in The Study

Table 2 shows the description and summary statistics of variables used in this study. It contains both the variables used for the first and second objective, i.e., variables used for the stochastic production frontier and the inefficiency model. The data indicates that approximately 52.5 % of maize farmers in the pooled sample are members of cooperatives. The sample includes farmers who are still in their active economic age, with an average age of 42 years old and an average of 12.9 years of farming experience. The average farm size of the farmers in the pooled sample is 7.2 hectares.

Furthermore, the table also presents the descriptive statistics and differences between members and non-members of the cooperatives. The results reveal that farm size, credit access, and extension visits are the variables that significantly differ between the two groups. Members of the cooperative have a larger average farm size of 8.36 hectares, compared to non-members who have an average of 6.1 hectares. Additionally, members of the cooperative have higher access to credit and extension visits than non-members. Access to credit and information in the form of extension visits are significant benefits of belonging to an agricultural cooperative, as previously mentioned in the study.

Moreover, the production variables also indicate that the average output of maize per hectare is notable. However, further analysis is required to examine the relationship between the variables and the output of maize per hectare. The results suggest that being a member of an agricultural cooperative can positively impact the output of maize per hectare due to the access to resources and information that members receive.

In summary, Table 2 provides valuable descriptive statistics of the variables used in the econometric study, with significant differences observed between members and non-members of agricultural cooperatives in terms of farm size, credit access, and extension visits.

Table 2.Description and summary statistics of variables

	Description	Pooled (n=299) Mean (SD)	Members (n=157) Mean (SD)	Non-members (n=142) Mean (SD)	Mean diff
Age	Age of the household head in years	42.71(10.23)	43.36(9.93)	41.99(10.5)	1.37
Education	Level of education. 1 for no formal education, 5 for tertiary level of education	3.26(1.29)	3.35(1.28)	3.15(1.31)	0.2
Gender	1 if the farmer is male, 0 if female	0.9(0.3)	0.91(0.29)	0.89(0.32)	0.02
Household size	Number of family members	5.15(2.03)	5.04(2.24)	5.26(1.76)	0.22
Farm size	Total farm size in hectares	7.24(8.21)	8.36(9.35)	6.01(6.65)	2.35**
Maize farming exp	Number of years in maize farming	12.88(9.04)	13.51(9.26)	12.5(8.76)	1.01
Maize farm size	Farm size cultivated with maize in hectares	4.57(4.33)	4.94(4.68)	4.17(3.89)	0.77
Credit Access	1 if the farmer has access to credit, 0 otherwise	0.46(0.5)	0.62(0.49)	0.29(0.45)	0.33***
Extension visits	A 5-point Likert scale of extension visits. 1 for low frequency, 5 for high frequency	2.41(1.09)	2.8(1.03)	1.98(0.99)	0.82***
Labor	Number of labors used	2.16(1.75)	2.09(1.56)	2.23(1.94)	0.14
Maize output	Value of total production of maize per hectare in 00,000' Nigerian Naira (NGN)	13.09(9.08)	13.47(9.49)	12.67(8.63)	0.80
Additional Labor	Value of hired labor per hectare used in 00,000' NGN	1.432(1.39)	1.50(1.49)	1.35(1.26)	0.15
Fertilizer	Value of fertilizer used per hectare in 00,000' NGN	1.36(1.08)	1.44(1.23)	1.27(0.87)	0.16
Machinery	Value of machine used in 00,000' NGN	5.60(7.63)	6.20(8.19)	4.94(7.02)	1.26
Pesticide	Value of pesticide used per hectare in 00,000' NGN	0.54(0.44)	0.54(0.41)	0.54(0.48)	0.00
Irrigation	1 if the farmer has access to irrigation, 0 otherwise	0.27(0.45)	0.36(0.48)	0.17(0.38)	0.00***
Seed	Value of seed used per hectare in NGN	0.24(0.24)	0.24(0.26)	0.24(0.21)	0.00
Soil fertility	A 5-point Likert scale of soil fertility. 1 for poor quality, 5 for good quality	4.02(0.45)	4.06(0.5)	3.99(0.39)	0.07
Water conservation	1 if the farmer practices water conservation, 0 otherwise	0.29(0.45)	0.37(0.48)	0.2(0.4)	0.17***

Note: *,**,* represents significance at 1 % , 5 % and 10% respectively**

4. Results

4.1. Results of Technical Efficiency and Stochastic Production Frontier Model for Unmatched Sample

Table 3 shows the maximum likelihood estimates of the stochastic production frontier using the unmatched samples. Since the results of the unmatched sample are prone to observable selection bias, it's important to run an estimation for the matched sample. Therefore, the sample for members and non-members are matched using propensity score matching as discussed in the next subchapter

Table 3. Maximum likelihood estimates of the Stochastic production frontier model using unmatched sample

Variables	Pooled		Members		Non-members	
Stochastic Frontier	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	7.443***	0.511	6.394***	0.724	8.405***	0.779
lnFertilizer	0.246***	0.047	0.358***	0.065	0.164***	0.057
lnPesticide	0.159***	0.055	0.130**	0.064	0.112	0.086
lnSeed	-0.057	0.056	-0.034	0.071	0.026	0.084
lnMaize farm size	0.341***	0.066	0.178	0.095	0.402***	0.093
lnLabor	-0.067***	0.019	-0.068**	0.029	-0.096***	0.025
ln Hired labor	0.179***	0.039	0.204***	0.056	0.136**	0.057
Irrigation	0.039	0.073	0.101	0.108	0.049	0.113
Cooperative membership	0.012**	0.063				
Inefficiency component						
Intercept	2.817*	1.470	1.142	1.567	0.981	0.702
Age	0.009	0.018	0.029	0.024	-0.003	0.005
Gender	-2.365	1.456	-1.722*	0.952	-0.535***	0.154
Education	-0.375	0.274	-0.292	0.141	0.053	0.041
Household size	-0.554*	0.332	-0.199	0.141	-0.152***	0.059
Access to credit	0.514	0.505	0.080	0.421	-0.187	0.129
Water conservation	-0.904	0.782	-0.430	0.473	-0.038	0.142
Soil fertility	-0.072	0.249	-0.158	0.286	0.164	0.143
Extension services	0.167	0.161	0.346	0.251	-0.025	0.048
Diagnostic statistics						
Lambda(λ)	3.024***	1.131	3.237***	1.027	0.265	0.415
Sigma-u(σ_u)	1.164***	0.423	0.977***	0.312	0.117	0.174
Sigma-v(σ_v)	0.385***	0.030	0.302***	0.052	0.442***	0.045
Gamma(γ)	0.901***	0.066	0.913***	0.050	0.066	0.192
Log likelihood function	-233.50		-121.53		-89.472	
Observations	299		157		142	

Note: *,**,* represents significance at 1 % , 5 % and 10% respectively**

4.2. Estimate of Propensity Score Matching

The probit regression model was utilized to estimate the propensity score matching for members and non-members of agricultural cooperatives. The resulting coefficients were computed and presented in Table 4, revealing that four explanatory variables - education, household size, access to credit, and extension services - has a significant impact on membership in cooperatives.

Table 4. Estimate of the probit regression

	Coefficient	Standard error
Intercept	-1.96***	0.51
Age	0.01	0.01
Education	0.16**	0.06
Gender	0.21	0.27
Maize farming experience	0.01	0.01
Household size	-0.11*	0.05
Farm size	0.01	0.01
Access to credit	0.64***	0.17
Extension services	0.40***	0.08
Pseudo R^2	0.56	

Note: *,**,* represents significance at 1 % , 5 % and 10% respectively**

4.3. Results of Technical Efficiency and Stochastic Production Frontier (SPF) Model for Matched Sample

Table 5 shows the maximum likelihood estimates of the stochastic production frontier using matched samples. Since the results of the unmatched sample are prone to observable selection bias, it's important to extensively discuss the result of the matched sample. The estimated result shows that the partial production elasticities of all the variables are positive except for seed and labour. These findings are in line with Olagunju et al. (2021) and Ahado et al. (2022) Cobb Douglas Production Frontier reports. A

likelihood ratio (LR) test was conducted to see if there are any technological differences between members and non-members. The likelihood ratio test is given as follows:

$$LR= -2\{\ln L_P-(\ln L_m+\ln L_n)\}$$

Where $\ln L_P$=value of log likelihood from pooled samples; $\ln L_m$=value of log likelihood from separate SPF for members; $\ln L_m$=value of log likelihood from separate SPF for non-members

The null hypothesis of the test is that there is no difference between the two group frontiers and the pooled frontier model. The likelihood ratio test resulted in the rejection of the null hypothesis of same technology between cooperative members and non-members (LR=42.13, P value <0.05), validating that separate frontier for members and non-members should be estimated. The result of the pooled estimation shows that cooperative membership is statistically significant and positive at 5 % level, indicating that cooperative membership is positively related to higher output of maize.

The result in the separate SPF shows that fertilizer, pesticide, maize farm size, unhired and hired labor are statistically significant and contribute to maize output for members and non-members. For members, fertilizer is the input variable that contribute the most to maize output i.e. A 100 % increase in fertilizer will lead to a 37 % increase in maize output. Hired labour contribute significantly to maize yield for members as a 100 % increase in hired labour leads to 28.5 % increase in output. For non-members of agricultural cooperative, maize farm size has the most elasticity, indicating that a 100% increase in maize farm size will lead to a 40.2 % increase in maize output. Another important variable worth mentioning is unpaid or family labour. It has a negative and statistically significant value for both groups, which implies that an increase in labor leads to a decrease in maize output.

The outcome of the technical inefficiency model estimation is displayed in the second section of Table 5. It's crucial to keep in mind that socioeconomic characteristics are used against technical inefficiency, which means that how they are interpreted in relation to technical efficiency will depend on the direction in which they are used. In other words, a negative sign for inefficiency implies a positive sign for efficiency. The bottom line is that factors with negative coefficients have a negative relationship with technical efficiency and consequently a positive influence on technical efficiency, and vice versa.

The factors affecting technical efficiency for non-members are gender and household size while for the members, only gender is the significant variable affecting technical efficiency. This result shows that gender (in this case being male) has a positive effect on technical efficiency. i.e., increases their technical efficiency in maize production for both members and non-members. Also, for non-members, household size also has a positive effect on technical efficiency of maize production. This can be due to multiple members of the household having additional information or resources towards contributing to technical efficiency.

Table 5. Maximum likelihood estimates of the Stochastic production frontier model using matched sample.

Variables	Pooled		Members		Non-members	
Stochastic Frontier	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Intercept	7.243***	0.525	5.601***	0.848	8.405***	0.779
lnFertilizer	0.241***	0.048	0.370***	0.071	0.164***	0.057
lnPesticide	0.173***	0.056	0.124*	0.066	0.112	0.086
LnSeed	-0.061	0.056	-0.027	0.076	0.026	0.084
lnMaize farm size	0.321***	0.068	0.102	0.111	0.402***	0.093
lnLabor	-0.065***	0.019	-0.073**	0.031	-0.096***	0.025
ln Hired labor	0.197***	0.042	0.285***	0.063	0.136**	0.057
Irrigation	0.040	0.075	0.130	0.112	0.049	0.113
Cooperative membership	0.016**	0.065				
Inefficiency component						
Intercept	2.340	2.016	0.763	1.192	0.981	0.702
Age	0.015	0.018	0.023	0.019	-0.003	0.005
Gender	-2.359	1.576	-1.257**	0.634	-0.535***	0.154
Education	-0.285	0.245	-0.092	0.145	0.053	0.041
Household size	-0.527	0.350	-0.095	0.105	-0.152***	0.059
Access to credit	0.309	0.413	-0.196	0.344	-0.187	0.129
Water conservation	-0.553	0.609	-0.125	0.336	-0.038	0.142
Soil fertility	-0.072	0.316	-0.173	0.250	0.164	0.143
Extension services	0.183	0.161	0.376	0.202	-0.025	0.048
Diagnostic statistics						
Lambda(λ)	2.922**	1.173	2.928***	0.896	0.265	0.415
Sigma-u($\boldsymbol{\sigma_u}$)	1.127**	0.441	0.770***	0.211	0.117	0.174
Sigma-v($\boldsymbol{\sigma_v}$)	0.385***	0.032	0.263***	0.064	0.442***	0.045
Gamma(γ)	0.895***	0.075	0.895***	0.057	0.066	0.192
Log likelihood function	-221.873		-107.996		-89.472	
Observations	299		142		142	

Note: *,**,* represents significance at 1 % , 5 % and 10% respectively**

4.4. Technical Efficiency Scores

In order to achieve objective 1, which involves analysing the technical efficiency of cooperative members and non-members. The analysis is based on different production frontiers, including pooled samples, members, and non-members, for matched and unmatched samples. The mean technical efficiency scores for each group are presented in Table 6, along with the mean technical efficiency difference and their corresponding percentage differences based on t-test for members and non-members.

The findings from the matched stochastic production frontier SPF estimations show that cooperative members operate at a mean TE level of 0.58, while non-members operate at a mean TE level of 0.73 relative to their respective group frontiers. These findings suggest that non-members are performing better within their own frontier than members, even after taking into account observable biases resulting from characteristics in the production frontiers. This indicates that non-members are utilizing their resources more effectively than members, at least in terms of their particular technology.

Table 6. Level of Technical efficiency levels across the SPF models

SPF model	Pooled	Members	Non-members	Test of means
Unmatched				
T.E score	0.70(0.17)	0.62(0.21)	0.73(0.18)	1.1422**(17.52%)
Matched				
T.E score	0.70(0.17)	0.58(0.21)	0.73(0.18)	1.1228**(27.12%)

4.5. Influence of Agricultural Cooperative on Technical Efficiency of Farmers

4.5.1. Who/What Influenced Members to Join Agricultural Cooperative?

Figure 6 shows the factors that influence farmers' decision to join agricultural cooperatives. The findings reveal that the majority of farmers (33.8 %) were influenced by family and friends to join the cooperative. This highlights the importance of social networks and relationships in shaping farmers' decisions to join cooperatives.

Furthermore, the study found that the leader of the agricultural cooperative also plays an important role, with 29.85 % of farmers citing the cooperative leader as an influence in their decision to join. This underscores the importance of strong leadership in fostering a supportive and motivating environment for farmers.

Additionally, the study found that a considerable proportion of farmers (23.88 %) joined the cooperative because of other farmers who already belong to the cooperative. This suggests that peer influence and social norms may also play a crucial role in shaping farmers' decisions to join cooperatives.

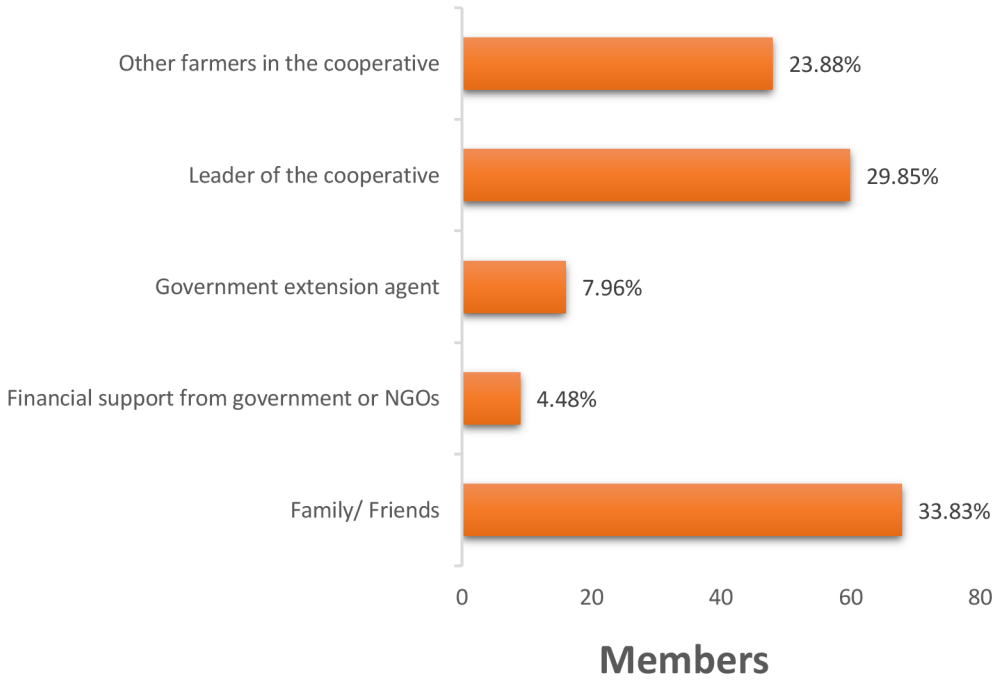

Figure 6. Who/what influenced members to join cooperative?

4.5.2. Benefits of Joining Agricultural Cooperative

According to the results presented in Figure 7, it is clear that joining an agricultural cooperative offers various benefits to farmers, as indicated by the Likert scale responses. About 69 % of the farmers agreed that joining the agricultural cooperative allows them to obtain improved services from input suppliers. It is well-known that inputs such as fertilizers, seeds, and pesticides are essential in farming, and being a member of an agricultural cooperative enables farmers to access these inputs at a lower cost, which ultimately leads to increased technical efficiency.

Moreover, the benefit that members most strongly agree with is the access to credit and saving facilities. Many farmers face financial constraints, and joining an agricultural

cooperative provides them with access to funds and loan services to expand their farms. This benefit is particularly important in promoting sustainable agricultural practices and ensuring that farmers have the resources they need to grow their businesses.

It is worth noting that a small percentage (12 %) of the members disagreed that they joined the agricultural cooperative for lesser time for marketing their farm produce. Nonetheless, it is evident that the benefits of joining an agricultural cooperative far outweigh the drawbacks, and farmers who become members are better positioned to improve their farming practices, access essential inputs, and obtain the necessary funds to grow their businesses.

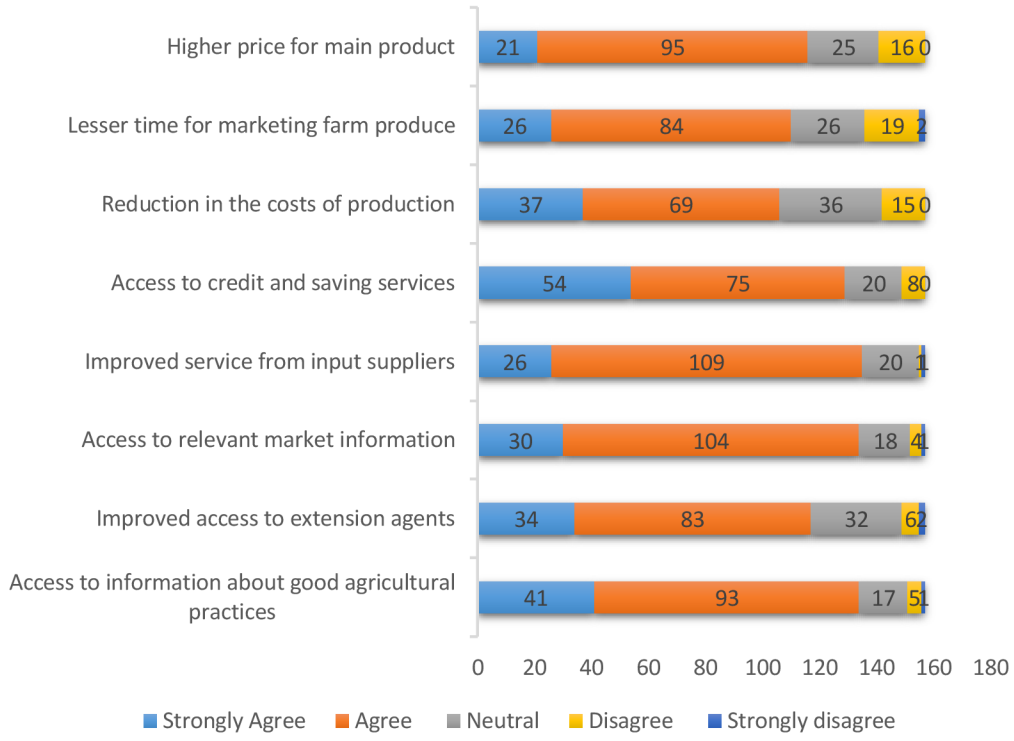

Figure 7. Benefits of joining agricultural cooperatives

4.6. Agricultural Cooperative Contribution to Technical Efficiency of Farmers

In order to understand how agricultural cooperatives, contribute to their members' technical efficiency, it is crucial to first have an understanding of how they are operated and managed. Key informants from the cooperative leadership in the study areas provided us with insight on this matter.

Through interviews conducted, it was found that agricultural cooperatives in various local governments in the area have an average of 30-50 members who are all farmers. These cooperatives have a leadership structure in place that oversees their operations and decision-making processes. Members make financial contributions to purchase inputs at a low cost, receive training on agricultural practices, and collectively

own agricultural land where they cultivate and share proceeds. Additionally, members have off-farm investments such as a warehouse that they rent out to make a profit.

However, the cooperatives face several challenges. One major challenge is the lack of financial support from both governmental and non-governmental organizations. This lack of support can make it challenging for the cooperatives to carry out their operations effectively. Another challenge is low commitment from members resulting in low attendance at meetings, which can hinder the effective functioning of the cooperatives. Finally, it is worth noting that the cooperatives market their products individually, which can be time-consuming and limit their ability to reach a wider market.

Despite these challenges, the cooperatives have found ways to fund themselves. They rely on contributions from individual members, establishment of off-farm businesses, and interest earned from cooperative savings. Profit from group activities is distributed among active members during annual general meetings. This approach has allowed the cooperatives to remain financially sustainable and continue to operate effectively.

5. Discussion

In this study, we aimed to assess the influence of agricultural cooperatives on the technical efficiency of farmers. Both quantitative and qualitative assessments were conducted to examine how agricultural cooperatives contribute to the efficiency of farmers, as well as the factors that influence farmers to join these cooperatives, with a special focus on the benefits that farmers can gain by becoming members.

The results of the study showed that several factors, including education, household size, access to extension services, and credit, play an important role in farmers joining agricultural cooperatives. However, we also found from the qualitative analysis that farmers can also be influenced to join cooperatives by their family and friends, as well as the leaders of the cooperatives. This highlights the importance of having well-educated leaders in agricultural cooperatives who are able to influence members to join. Additionally, the study revealed that farmers are primarily motivated to join agricultural cooperatives due to the benefits they can receive. Specifically, access to information on agricultural practices was identified as the most important factor for farmers. This highlights the crucial role that agricultural cooperative can play in providing important information and resources to their members.

Furthermore, the study revealed that agricultural cooperatives have different functions that they provide to their members. Some cooperatives prioritize offering training programs to their members, while others focus on improving the lives of their members through both farm and off-farm enterprises. This suggests that agricultural cooperatives can be tailored to meet the specific needs and preferences of their members. Overall, this study provides important insights into the factors that influence farmers to join agricultural cooperatives and the ways in which these cooperatives can contribute to

the technical efficiency of farmers. By understanding these factors and tailoring the services provided by agricultural cooperatives, it is possible to increase their effectiveness in supporting farmers and promoting sustainable agriculture.

A stochastic production frontier was estimated for both the matched and unmatched sample using maximum likelihood. However, it was noted that the unmatched sample is vulnerable to observable bias, and therefore, the discussion will be based solely on the results from the matched sample. As mentioned in the previous chapter, the Cobb Douglas functional form was used in this study, and it was found to be more appropriate compared to the translog functional form after a likelihood ratio test was conducted in favour of the former. The result in the separate SPF shows that pesticide, maize farm size, unhired and hired labor are significant variables that contribute to maize output of member and non-member farmers. These variables all have a positive relationship with maize output except unhired labor which in this case can be family labor or not. This negative relationship between unhired labor and maize output can be attributed to the fact that adding more unpaid labor beyond a certain point without direct incentives may have negative effects and eventually lead to reduced output. Additionally, farmers sometimes compensate for this labor in kind, which may result in overpayment and decreased output. Furthermore, the law of diminishing returns suggests that as more family labor is added to the maize production process, the marginal product of labor will eventually decrease. This observation is consistent with previous research conducted by Kassie et al. (2013).

The study conducted an analysis of the factors that affect the technical efficiency of maize farmers in agricultural cooperatives. The results showed that both gender and household size were significant variables affecting the technical efficiency of both member and non-member farmers. However, household size was only significant for non-

members. The gender of the farmers was found to be an important factor in determining technical efficiency. Studies have shown that men and women often have different access to resources, which can influence their efficiency in farming. Similar result was reported in a previous study conducted by Ahado et al. (2022) in Mongolia, which found that gender plays a role in determining the technical efficiency of farmers. Household size was also found to be a significant factor affecting the technical efficiency of non-members of agricultural cooperatives. This is because the size of a household can affect the availability of resources and labor. Previous study conducted by Adeola Obayelu et al. (2022) in Nigeria found similar result, which indicated a positive relationship between household size and technical efficiency in maize production.

In comparing the mean technical efficiency scores between agricultural cooperative members and non-members, the estimates of the results showed that the mean technical efficiency scores of non-members were significantly higher than members. Based on the responses received from the cooperative members and leaders, it was discovered that some members join the cooperative solely for the purpose of gaining access to agricultural loans, which may hinder the effectiveness of the cooperative since such members tend to have a low commitment to the organization. This could explain why non-members tend to have a higher level of technical efficiency than members.

Additionally, it was found that non-members also have access to some of the information that is passed to the cooperatives. Some members only join the cooperative to take advantage of the availability of inputs and agricultural loans. Their incentive to join the cooperative is short-term, making it difficult for them to commit to the cooperative in the long run.

Moreover, off-farm diversification was also identified as a contributing factor to non-members having higher technical efficiency than members. Agricultural cooperatives tend to divert their objective from growing farming enterprise to livelihood improvement, making it difficult to expand agricultural production but expanding off-farm enterprises instead. This diversion could be a factor in the lower technical efficiency of cooperative members.

This finding is consistent with the research conducted by Adjin & Henning (2021), which found that non-members of agricultural cooperatives had higher technical efficiency in maize production than cooperative members. These studies suggest that differences in access to information, training, capital, and technology may be contributing factors. However, these results contradict the findings of Abdul-Rahaman & Abdulai (2018); Ma et al. (2018); Olagunju et al. (2021), who found that cooperative members were more technically efficient than non-members. The study suggests that there may be variations in technical efficiency among cooperative members and non-members, and the results may be influenced by the specific context and technology used. production.

Table 7. Summary of fulfilment of objectives

Aims	Methodology	Results
To estimate the technical efficiency of maize production among cooperative farmers in comparison with non-members of cooperatives	Stochastic production frontier- Cobb Douglas functional form	Non-members of agricultural cooperative have a higher technical efficiency compared to members
To analyse factors affecting technical efficiency in maize production in the cooperatives.	Stochastic production frontier- Cobb Douglas functional form Inefficiency model	Gender and household size are the factors affecting technical efficiency
To describe the influence of cooperative in improving the technical efficiency of farmers.	Explanatory Research	They have an established leadership structure They support members through; agricultural trainings, provision of inputs at cheaper price, agricultural loan.

5.1. Recommendation

On the basis of the research's findings, recommendations for policy implications are made.

The issue of agricultural cooperatives in Oyo state, Nigeria requires attention, as many organizations registered as agricultural cooperatives do not fully understand the concept and how it differs from credit organizations or ordinary cooperatives. It is essential to revisit the concept of agricultural cooperatives to ensure that organizations registered as such understand what it entails and how it can improve the livelihoods of their members through on-farm activities. Many agricultural cooperatives in Oyo state have diverted their focus from the primary objective of improving livelihoods through on-farm activities, which has deterred members from rendering services that they joined for in the first place. Therefore, it is important for the state government authority responsible for giving agricultural cooperative licenses to ensure that these groups understand the concept of cooperative by providing further training on cooperative practices. This will enable them to refocus on the primary objective of improving livelihoods through on-farm activities, which will benefit both the members and the agricultural sector as a whole.

Also, government can improve agricultural cooperatives by providing support and resources for cooperative development, such as training programs and financial assistance. They need to provide assistance not just by providing loans to farmers but also by providing inputs. More so, they can establish a regulatory framework to protect the rights of cooperative members and encourage partnerships with other stakeholders. This could involve creating laws and regulations that govern the formation and operation of cooperatives, as well as setting up oversight mechanisms to monitor their activities

Additionally, raising awareness of the benefits of cooperative membership can help farmers and the wider community. Government could also encourage the formation of partnerships between agricultural cooperatives and other stakeholders, such as private companies, research institutions, and non-governmental organizations. These partnerships could provide cooperatives with access to new markets, technology, and expertise, as well as support for sustainable agriculture practices.

5.2. Limitations of Study

Despite the fact that the research paid close attention to critical details, it is necessary to acknowledge some of its shortcomings. Firstly, the research objectives were structured to measure the influence of technical efficiency on cooperative farmers, without any reference to active and inactive members. This limitation was realized during the process of data collection and analysis. Although the literature suggests that agricultural cooperatives can increase technical efficiency, the fact that some members were inactive did not allow for capturing the effect of cooperative membership in its entirety.

Additionally, the sample size of the data used in the research was not sufficient for controlling and treatment groups, and it appeared that they had the same size. Moreover, the research focused more on agricultural cooperative members than non-members, which could have resulted in a biased dataset. To mitigate this, the research attempted to control for biases by using observable characteristics and propensity score matching. However, it is important to note that unobservable characteristics, which play a significant role in accounting for biases according to the literature, were not taken into consideration in this study.

In brief, while the research paid close attention to critical details, it is essential to acknowledge its limitations. These include the failure to account for the impact of inactive members, the small sample size, and the focus on observable characteristics at the expense of unobservable characteristics that could have influenced the findings.

5.3. Suggestion for Further Research

The suggestion for further research in this study aims to address the limitations discussed above.

Firstly, future studies could be designed to account for the impact of both active and inactive members in agricultural cooperatives, rather than combining them together. This could involve collecting data on both groups separately and analysing their impact on technical efficiency.

Additionally, larger sample sizes could be used in future studies to ensure that there are sufficient participants in both the control and treatment groups. This would help to reduce the risk of bias and increase the accuracy of the findings.

Thirdly, future research could aim to balance the focus between agricultural cooperative members and non-members, to ensure a more balanced dataset. This could involve including more non-members into the sample.

Finally, future research could aim to account for unobservable characteristics that could influence the findings. This could involve using more advanced statistical techniques such as sample selection and meta frontier approach to control for biases or collecting more detailed data on individual characteristics that could impact technical efficiency.

6. Conclusion

In this study, the technical efficiency of maize farmers in Oyo state, Nigeria, was assessed to determine the impact of agricultural cooperatives on their efficiency. The research aimed to estimate the technical efficiency of both members and non-members of agricultural cooperatives and compare the factors that influence their technical efficiency, as well as how cooperatives contribute to the differences.

The results of the study showed that non-members of agricultural cooperatives had a higher technical efficiency than members, despite the fact that members had a higher maize output than non-members. The only significant factors that influenced technical efficiency were gender and household size. However, the qualitative analysis of key informants in cooperative leadership provided insights as to why members had a lower technical efficiency compared to non-members.

It was revealed that farmers joined agricultural cooperatives primarily to take advantage of agricultural loans, which often made them inactive after collection. Additionally, agricultural cooperatives tend to shift their focus from growing farming enterprises to improving livelihoods, which could also negatively impact technical efficiency.

Education, credit access, extension services, and household size were identified as the key factors that influence farmers to join cooperatives. However, the qualitative analysis also showed that friends/family and leaders of cooperatives had a significant influence on farmers' decisions to join cooperatives. Farmers also joined agricultural cooperatives to access several benefits, most of which were not being fulfilled by the organization.

Despite these findings, agricultural cooperatives remain important tools for improving farmers' technical efficiency. They provide farmers with access to agricultural loans, information, market their produce and cheaper inputs. These are some of the reasons why farmers joined cooperatives in the first place. However, it is crucial that agricultural cooperatives adhere to the principles that guide their operations to fully explore these benefits. Without doing so, the desired effect on technical efficiency cannot be realized

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8. Appendices

List of the Appendices

Appendix 1: Questionnaire

Appendix 2: Key Informant Interview Questionnaire

Appendix 1: Questionnaire

Questionnaire number:……..

Name of village/ community: ……

GPS: ……

A. SOCIO ECONOMIC AND FARM INFORMATION

1. Age of respondent (years)? _____
2. Gender Male [ ] Female [ ]
3. What is your highest level of education? No formal education [ ] primary education [ ] junior secondary education [ ] senior secondary education [ ] tertiary education [ ]
4. What is your household size(counts)? _____
5. What is your marital status? Single [ ] Married [ ] Divorced [ ] Widowed [ ]
6. What is the number of years you have spent in maize farming? _____
7. What is your total farm size (in hectares)? _____
8. What is the distance from your farm to the nearest market? _____
9. Did you have access to farm credit in the last growing season? Yes [ ] No [ ]
10. Do you have access to irrigation? Yes[ ] No [ ]
11. How often do you get access to extension services/visits? Once per month [ ] Once in 3 months [ ] once in six months [ ] once in a year [ ]
12. Do you have access to television and radio coverage? Yes [ ] No [ ]
13. Are you aware of credit sources information? Yes [ ] No [ ]
14. Are you willing to try new farming methods? Yes [ ] No [ ]

B. INSTITUTIONAL FACTORS: AGRICULTURAL COOPERATIVE INFORMATION

15. Do you belong to any agricultural cooperative organization? Yes [ ] No [ ]
16. How long have you been in this cooperative? _____

Why did you join this agricultural cooperative?

Statement	Yes/No

17. Family/ Friends	
18. Leader of the cooperative	
19. Financial support from government or NGOs	
20. Government extension agent	
21. Other farmers in the cooperative	

How have you benefitted from this agricultural cooperative?

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
22. Your farm income has increased					
23. You accessed higher quality inputs at a lower price					
24. You receive higher price for your main product					
25. Lesser time for marketing farm produce					
26. You have reduction in the costs of production					
27. You have better access to credit					

and saving services					
28. Service from input suppliers has improved					
29. Access to relevant market information have improved					
30. Service from extension agents have improved					
31. Access to information about good agricultural practices has improved					

C. PRODUCTION INFORMATION

1. What is the value of total production of maize in Nigerian naira? _____
2. What is the value of fertilizer used in naira? _____
3. What is the value of pesticides used in naira? _____
4. What is the value of seed used in naira? _____
5. What is the size of family labour that work on the farm? _____
6. What is the value of farm labour used in naira? _____
7. What is the total area of land cultivated with maize(hec)? _____
8. What is the value of farm machinery used on the farm? _____

D. AGROECOLOGICAL FACTORS

1. Do you cultivate maize on a good and favourable soil ? strongly agree [ ] agree [ ] neither agree nor disagree [ ] disagree [ ]strongly disagree [ ]
2. Do you practise water conservation Yes [ ] No [ ]

3. Are you affected by drought strongly agree [ ] agree [ ] neither agree nor disagree [ ] disagree [ ]strongly disagree [ ]
4. Are you affected by pest and diseases strongly agree [ ] agree [ ] neither agree nor disagree [ ] disagree [ ]strongly disagree [ ]

Appendix 2: Key Informant Interview Questionnaire

Name of cooperative: …….

Number of members: …….

Name of village/ community:……

1. Can you describe the main business of cooperative and its services/benefits for members?
2. When was the cooperative established/registered? (year)
3. Can you describe the governance system of the cooperative? How frequent meetings are held
4. What is the composition of members - all farmers?
5. What was the initial investment from members? Was the investment even among members?
6. What are the main assets and facilities of the cooperative
7. What are the main challenges for cooperative (as a group and for business) now
8. Is the number of members increasing
9. How many hours per week do you spend with cooperative matters?
10. What is the main income of the cooperative to cover the running cost of the group?
11. What is the system of payments between cooperative and members? Does the cooperative have money for purchase of members produce?
12. How do members pay for services and renting of assets from the cooperative - e.g., trailers, tractor, car, processing, storage?
13. Is there any profit created by the cooperative?
14. How is profit used in the cooperative?