

**EFFECTS OF CHOICE OF MILK MARKETING OUTLET ON SMALLHOLDER
DAIRY FARMERS' CREDIT MARKET PARTICIPATION AND INCOMES IN
WESTERN KENYA**

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**A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for
the Master of Science Degree in Agribusiness Management of Egerton University**


EGERTON UNIVERSITY

NOVEMBER, 2024

DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been presented in this University or any other for the award of degree.

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DEDICATION

This thesis is dedicated to my beloved family for their unwavering love and support. To my late father, Sylvester Nyagilo, whose memory continues to inspire me, and my wonderful mother, Winfred Atieno, for her endless encouragement. To my brothers, Modestus, Gerald and Omondi, and my niece, Patience, whose presence brings joy and strength to my life. Lastly, to my late uncle, Peter Nyagilo, whose kindness and guidance have left a lasting impact—this work is in honor of all of you.

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to Egerton University for giving me the opportunity to pursue my studies at this esteemed institution. Special thanks go to the Department of Agricultural Economics and Agribusiness Management for their significant contribution to the achievement of my academic goals.

I extend my sincere appreciation to the Center of Excellence in Sustainable Agriculture and Agribusiness Management (CESAAM) for awarding me a scholarship that enabled me to pursue my Master of Science in Agribusiness Management. I am also deeply grateful to the International Livestock Research Institute (ILRI) for their financial support during my fieldwork. My special thanks go to my supervisors, Prof. G. Owuor, Dr. J. Rao and Prof. D. Jakinda, for their invaluable guidance and unwavering support, which made this work possible. I am also indebted to Mr. Auma Joseph (ILRI) and the entire team who assisted me during data collection.

ABSTRACT

Cooperative societies play a crucial role in bringing people together from diverse backgrounds to achieve common goals. These societies are key to Africa's economic development, particularly through improving food security, providing inputs, financial services and influencing policies. By acting collectively, smallholder farmers benefit from reduced transaction costs, increased access to better markets, and enhanced bargaining power. Despite efforts by the County Governments of Homa Bay and Nyamira to enhance milk production and marketing through registered dairy cooperatives, some smallholder dairy farmers still choose to sell their surplus milk to alternative outlets rather than cooperatives. This results in the underutilization of cooling plants, negatively impacting the cooperatives' viability and their SACCOs. The specific objectives of this study were to: (1) determine the factors that influence smallholder dairy farmers' choice of milk marketing outlets; (2) analyze the effects of selling to cooperatives on farmers' credit market participation; and (3) assess the effect of the choice of fresh milk marketing outlets on smallholder dairy farmers' incomes. Primary data was collected in Borabu and Rachuonyo South Sub-Counties using semi-structured questionnaires. Yamane's (1967) formula for sample size determination was used to obtain a sample size of 277 households, comprising 153 respondents from Borabu and 124 from Rachuonyo South. Data analysis was conducted using a combination of descriptive statistics, Multivariate Probit, Binary Logit, and Endogenous Switching Regression models. The Multivariate Probit analysis indicated that variables such as age, farming experience, distance to nearest market centers, number of lactating cows and price per litre significantly influenced the choice of milk marketing outlets. The Binary Logit model highlighted that gender, access to extension services, farm size and association membership were significantly influenced the probability of credit market participation. The final analysis demonstrated that off-farm income, years of schooling and herd size positively affected farmers' income. The Average Treatment Effect on the Treated (ATT) showed that cooperative participation increased farmers' income by 9%. The study recommended improving access to milk collection centers, stabilizing pricing and ensuring timely payment to farmers. In addition, strengthening cooperatives' roles in providing financial services, particularly for women and supporting income diversification initiatives would further enhance credit market participation and household incomes.

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LIST OF ABBREVIATIONS AND ACRONYMS

ATT	Average treatment effect for the treated
ATE	Average Treatment Effect
ATU	Average Treatment on the Untreated
ICA	International Cooperative Alliance
ILRI	International Livestock Research Institute
KCC	Kenya Cooperative Creameries
KDB	Kenya Dairy Board
ESR	Endogenous Switching Regression
KNBS	Kenya National Bureau of Statistics
BH	Base heterogeneity
TH	Transitional Heterogeneity
FBO	Farmer Based Organization
PSM	Propensity score matching
RUM	Random Utility Model
RUT	Random Utility Theory
ICA	International Cooperative Alliance
IPWAR	Inverse Probability Weighted Adjusted Regression model
OLS	Ordinary Least Squares

CHAPTER ONE

INTRODUCTION

1.1 Background information

Cooperative societies play a crucial role in bringing together individuals from diverse backgrounds to achieve common goals. These societies are key to Africa's economic development, particularly through improving food security, providing inputs, financial services and influencing policies (Ton *et al.*, 2016). In Kenya, dairy cooperatives dominate formal milk marketing by collecting, bulking, cooling, and transporting milk from smallholder farmers and selling it to processors (Kenya Dairy Board, 2014). Cooperatives also ensure milk quality and safety, preventing harmful impacts on consumers when standards are not met (Nyokabi *et al.*, 2021).

By acting collectively, smallholder farmers benefit from reduced transaction costs, increased access to better markets and enhanced bargaining power (Fischer *et al.*, 2012). Cooperatives handle 55% of the total milk sold formally, while medium and large producers contribute the rest, producing higher volumes (Rademaker *et al.*, 2016). Beyond cooperatives, farmers sell milk through middlemen, processors and directly to consumers. Many cooperatives offer members credit advances through a "check-off system" against future milk payments. Additionally, the Kenyan government, through public-private partnerships, has distributed over 350 milk coolers to dairy cooperatives, improving milk preservation (Kenya Dairy Board, 2019).

In Nyamira County, the Borabu Farmers' Cooperative Union, established in 1982, plays a pivotal role in milk marketing, credit provision, and input supplies. The union is made up of several cooperatives and owns a 5,000-litre cooling plant, selling its milk to the New Kenya Cooperative Creameries (NKCC). The NKCC has partnered with Vision Point Microfinance Institution to facilitate farmer payments (Nyamira CIP, 2018; Ong'aro, 2012). The farmers were also supported by the Smallholder Dairy Farmer Commercialization Programme

In neighbouring Homa Bay County, dairy cooperatives are re-emerging, with support from public-private partnerships. According to Homa Bay County Integrated Plan, (2018), a large number of the producer cooperative societies are inactive while some have collapsed. KASBONDO AIM and RANGWE Dairy Cooperatives, supported by the Feed the Future Accelerated Value Chain Development project, have adopted modern technologies like artificial

insemination and fodder production to boost milk yields (ILRI, 2018). Unlike Borabu Union, KASBONDO adds value to its milk and has developed its own brand of products.

Improved milk production and reliable markets are expected to enhance household income and support access to credit through cooperative SACCOs or external sources. However, the impact on income and credit market participation may vary depending on the chosen milk market outlet, as transaction terms differ across outlets. Therefore, this study aimed to evaluate how the choice of milk market outlet affects the income and credit marketing participation capabilities of smallholder dairy farmers.

1.2 Statement of the problem

Despite efforts by the County Governments of Homa Bay and Nyamira to enhance milk production and marketing through registered dairy cooperatives, some smallholder dairy farmers still choose to sell their surplus milk to alternative outlets rather than the cooperatives. This results in the underutilization of cooling plants negatively impacting the cooperatives' viability and their SACCOs. It is unclear what determines milk marketing outlet choice by farmers and how participation in milk marketing impacts, participation in the credit market participation and household incomes. This study, therefore, sought to determine factors that influenced the choice of milk market outlets and the impact of choice on credit market participation and income. The information will help the management of cooperatives to design incentives for increased milk supply by farmers in their catchment.

1.3 General objective

To contribute to food security through increased milk production, marketing and increased incomes in Nyamira and Homa Bay counties

1.3.1 Specific Objectives

- i. To determine factors that influence smallholder dairy farmers' choice of milk marketing outlets in Nyamira and Homa Bay counties.
- ii. To analyse the effects of selling to the cooperatives on farmers' credit market participation-borrowing and loan repayment in Nyamira and Homa Bay Counties
- iii. To assess the effect of the choice of fresh milk marketing outlets on smallholder dairy farmers' incomes in Nyamira and Homa Bay Counties

1.4 Research questions

- i. What factors influence smallholder dairy farmers' choice of fresh milk marketing outlets in Nyamira and Homa Bay Counties?
- ii. What is the effect of selling to the cooperatives on farmers' credit market participation in Nyamira and Homa Bay Counties?
- iii. What is the effect of the choice of fresh milk marketing outlets on smallholder dairy farmers' incomes in Nyamira and Homa Bay Counties?

1.5 Justification of the study

Dairy cooperatives play an important role in linking farmers to a reliable market, providing credit services, input provision and extension services thus enabling improvement in milk production. Organized farmers in cooperatives can bargain for better prices for their milk and pool resources to start their processing plants and value-adding activities. However, dairy cooperatives often face low and/or partial participation by farmers, compromising their viability and utility in delivering promised services. Hence this study sought to understand barriers to farmer participation in cooperatives and if participation impacted farmer household livelihood outcomes such as income and credit market participation. This study will contribute toward realizing Sustainable Development Goals 1 and 2; no poverty and zero hunger, respectively, through increased incomes. In addition to the realization of the Bottom-Up Economic Transformation Agenda by the Kenyan Government.

Additionally, the study will provide insights into the management of dairy cooperatives on appropriate policies for increased participation by farmers and hence the viability of cooperative milk marketing business. Increased participation by farmers will also enhance credit management, enabling many farmers to avoid loan defaults. In addition, County Governments and their development partners will be able to understand the impacts of their support in improving dairy value chains on smallholder dairy farmers' livelihoods.

1.6 Scope and limitations of the study

This study targeted smallholder dairy farmers who are members of cooperatives in Borabu and Rachuonyo South Sub-Counties. Due to the global COVID-19 pandemic, credit access for smallholder farmers may have been severely constrained. The pandemic led to economic slowdowns, which affected financial institutions' ability to extend credit and also

reduced farmers' ability to repay loans. This context may have introduced bias in understanding the real challenges of credit access under normal circumstances.

The smallholder dairy farmers in Borabu and Rachuonyo South Sub-Counties spoke local languages, which could have created communication challenges during the data collection process. To overcome this, we employed a translator to ensure that respondents fully understood the questions and could provide accurate information.

1.7 Definition of Terms

Private milk traders: Hotels, milk bars, middlemen and institutions

Other milk marketing outlets: refers to direct consumers and private milk traders

CHAPTER TWO

LITERATURE REVIEW

2.1 Smallholder Dairy Farming in Kenya

The dairy industry in Kenya is the fastest-growing sub-sector and the largest contributor to the agricultural gross domestic product (GDP). The sub-sector is dominated by smallholder dairy farmers who own 2-15 lactating cows and produce more than 80% of the total milk production in the country. This sub-sector also provides a means of livelihood to about 1.7 million Kenyans (Ministry of Agriculture, Livestock and Fisheries, 2019). According to USAID (2016), the sub-sector plays an important role in poverty eradication. In terms of milk consumption, Kenya has the highest per capita compared to the other East African countries which is currently at 125 litres annually (Merem *et al.*, 2022). Uganda comes next with a capita milk consumption of 62 litres while Tanzania has 47 litres. The average milk consumption per capita is projected to double by 2030. To meet the growing demand for milk due to rapid urbanization and the growing middle-class population, domestic production has increased by about 5.8% annually (Bebe *et al.*, 2017).

The production systems adopted by smallholder dairy farmers range from stall-fed cut-and-carry to commercial supplement concentrates and free grazing on natural pastures (Wambugu *et al.*, 2011). The population density and the ecological zones influence the production system adopted (Staal *et al.*, 2003). Farmers in the Kenyan Highlands carry out intensive zero-grazing because of the dense population compared to moderately populated medium potential areas where semi-intensive zero-grazing is carried out (Mbugua *et al.*, 1998). Bebe *et al.* (2003) found that farmers with land sizes less than 2.5 ha carry out intensive zero-grazing. Land size also determines the number of dairy animals the farmers keep and the labour requirement (Otieno, 2020).

A large number of dairy farmers keep pure breeds such as Friesian, Guernsey, Ayrshire, and Jersey and their crosses for milk production (Kibiego *et al.*, 2015). The rural poor in Kenya depend on agriculture as the main source of livelihood. More than 75% of smallholder dairy farmers' household heads depend exclusively on dairy farming as their primary occupation (Maina *et al.*, 2020; Otieno 2020). A Study by Odhiambo *et al.* (2019) and Ongwech *et al.* (2020) found that more than half of smallholder dairy farmers in Kenya are male. Smallholder dairy farmers are also literate with basic education from primary and secondary. This is

consistent with Odhiambo *et al.* (2019), who revealed that more than half of dairy farmers had attained primary and secondary school education. Ongwech *et al.* (2020) also revealed that half of the dairy farmers in Kenya had 1-8 years of schooling while 41.74% had 9-16 years of schooling and the remaining percentage had no formal education.

Ongwech *et al.* (2020) found out that 90% of the dairy farmers were married and the mean age of dairy farmers was 50.69 with a minimum age of 20 years and a maximum of 80 years. The average years of farming experience were found to be 15.56 years with the minimum years of experience being 10 and a maximum of 38.

2.2 History of Cooperatives

The history of cooperatives in Kenya dates back to the precolonial period, with the establishment of the first cooperative society by European settlers in the Rift Valley. This cooperative, known as the Lumbwa Cooperative, was formed to facilitate the acquisition of agricultural inputs and the marketing of produce, leveraging economies of scale (Kenya Yearbook Editorial Board, 2023). In 1931, following the promulgation of the first Co-operative Ordinance, several key cooperatives were established, including the Kenya Creameries (KCC), the Kenya Farmers Association (KFA), and the Kenya Planters Cooperative Union (KPCU). These organizations were integral in supporting farmers by providing inputs and marketing services. The Swynnerton Plan of 1954 further spurred the formation of numerous producer and marketing cooperatives to enhance agricultural productivity and support smallholder farmers.

As of 2022, the State Department of Cooperatives in Kenya reports over 22,833 registered cooperatives, with only 30% focused on agriculture. These agricultural cooperatives serve various functions, including marketing, banking, and providing savings and credit services. Specifically, the dairy sector has 412 registered dairy cooperatives, with membership ranging from 30 to 2,000 households (International Cooperative Alliance, 2023). These cooperatives play a crucial role in formal milk marketing, handling processes such as collecting, bulking, transporting, cooling, and processing milk from smallholder farmers.

Despite their significant contribution, the cooperative sector in Kenya faces numerous challenges, including governance issues, inadequate funding, and the need for value-added production. The government has initiated reforms to improve the regulatory framework, enhance cooperative governance, and promote the sustainable development of cooperative enterprises,

aiming to strengthen their capacity to support local economies and food security (International Cooperative Alliance, 2023)

2.3 Importance of producer organizations in milk marketing

Producer organizations play an important role in Kenya's formal milk market. According to the Kenya Dairy Board (2014), more than half of milk produced by smallholder dairy farmers is marketed through producer organizations. In addition, approximately 360 self-help groups and cooperatives collect, bulk, and market-fresh milk to processors. The majority of milk sold to processors is from cooperative societies. The perishable nature of milk requires faster and more efficient access to the market to reduce losses. Smallholder dairy farmers acting collectively can reduce transaction costs involved in searching for markets, securing new technologies, tapping into better markets and increasing their bargaining power (Fischer *et al.*, 2012).

Processors' requirements regarding the quality of milk are passed to smallholder dairy farmers through cooperatives (Ton *et al.*, 2016). The low-quality milk that does not meet the required food safety and quality standards causes great harm to consumers. This could be due to high bacterial count, aflatoxins and antibiotic residues and zoonotic pathogens (Kabui, 2012; Kaitibie *et al.*, 2008; Nyokabi *et al.*, 2021). Cooperatives ensure member farmers adhere to the quality requirement and often reject milk from farmers who do not meet the criteria. Farmers also peer- monitoring one another to ensure compliance.

In areas far away from market centres, dairy cooperatives provide a means of reaching the market by collecting milk from farmers and marketing on their behalf. A study by Shiferaw *et al.* (2008) showed that farmers living away from the trading centres prefer to sell to cooperatives in their neighbourhood to avoid milk spoilage. Although cooperative societies may at times be offering low prices than other players in the market, they provide a stable price for farmers during glut season

2.3 Factors that influence the choice of fresh milk marketing outlet by smallholder dairy farmers

The high perishable nature of fresh milk demands efficient transportation to cooling plants and markets to prevent spoilage. Smallholder dairy farmers must choose between formal and informal marketing outlets, often based on their specific household characteristics and the

associated transaction costs (De Janvry *et al.*, 1991). A variety of endogenous and exogenous factors, including price, market accessibility, and socioeconomic variables, influence farmers' marketing decisions (Cheelo & van der Merwe, 2021). Farmers tend to select the outlet that maximizes their utility, which typically means maximizing profit while minimizing transaction costs.

Taye *et al.* (2016) used Multivariate Probit to determine Milk Market Outlet Choices in Ethiopia. Their study found three preliminary milk marketing outlets: small traders, hotels and individual buyers. The results indicated that the education of the household head, number of lactating cows, distance to the nearest urban center, the total land holding, family size and sex of the household head had a positive and significant effect on the choice of milk marketing outlet. The authors indicated that the predicted probability of choosing a small trader channel was lower than individual and hotel channels. The model used enabled the correlation between the market outlet choices to be estimated jointly.

Kumar and Parappurathu (2018) used a Multinomial Logit to determine factors influencing the choice of milk marketing outlets. The results indicated that education attainment, price per litre, access to institutional credit, participation in the public distribution system and membership in social groups positively and significantly affected the choice of milk marketing outlets. The total land holding and milk produced per year did not substantially affect the cooperatives' choice. The study further suggested that farmers with larger household sizes were less likely to sell through the cooperatives than other marketing outlets. The reasoning behind this is that larger households may have more labour, enabling farmers to sell to other outlets that offer higher prices. Berem *et al.* (2015) using the same model found similar results: education, milk price and household size influenced the choice of milk marketing outlets. The Multinomial Logit model assumed that the farmers chose to sell to single marketing outlets. However, there is a possibility that a farmer can sell to more than one marketing outlet. This study uses Multivariate Probit because it allows farmers to choose multiple milk market outlets.

Cheelo *et al.* (2021) using Multinomial Logit identified that gender, education, off-farm income, distance to market, the volume of milk produced and price of milk influenced the milk marketing outlet in Zambia. The authors compared the choice of modern milk marketing outlets (cooperatives and processors) with traditional markets (direct consumers). The findings indicated that female farmers were more likely to sell through traditional outlets, while higher

education levels increased the likelihood of choosing modern outlets. Additionally, greater distance to the market and off-farm income reduced the likelihood of using traditional outlets. Similarly, Kumar *et al.* (2019) suggested that education level and price of milk influenced the choice of milk marketing outlets.

Belay (2020) utilized probit model to determine the factors that influence farmers participation in cooperative societies and Heckman two-stage estimation to check for intensity of participation. The results revealed that age, no of children, dairy cow number, land size, distance to nearest market centres and performance of the cooperatives influenced participation in cooperatives. The factors that influenced intensity of participation included number of children below six years, age, trust, distance to nearest market centres and access to extension service. In this study, we utilized the same variables apart from the cooperative performance because the cooperatives in the study area were the best and the active ones in the region.

In a study conducted in Kuresoi North Sub-County, Kenya, Kurgat *et al.* (2023) used the Multinomial Logit model to explore factors influencing formal milk market participation. Their results showed that occupation, number of cows, milk volumes produced, price per liter, off-farm income, distance to market, and group membership were positively associated with formal market participation. The study also found that households with a higher number of adults were less likely to sell milk to formal markets. On the other hand, informal market participation was influenced by the type of cow breed and market distance, with larger milk volumes, off-farm income, group membership, and credit access reducing the likelihood of choosing informal markets. This study fills a gap in the literature by identifying the factors that influence the choice of milk marketing outlets among farmers who are members of cooperatives. While limited research has been conducted on these factors, most existing studies focus on comparing cooperatives to non-cooperative models, rather than examining the specific dynamics within cooperative membership.

2.4. Smallholder dairy farmer credit market participation

The inability of dairy farmers to borrow loans due to their limited resources was identified as one of the major constraints affecting smallholder dairy farmers' ability to invest in milk production (Rademaker *et al.*, 2016). On-farm investments by smallholders in Africa were primarily financed through household savings and income from off-farm activities. Barriers to smallholder access to formal credit included low productivity, high risk, trust in financial

institutions, and lack of collateral, especially for women who were underserved by formal financial institutions (Stupnytska, 2019). Formal financial institution lending to the agricultural sector in Kenya accounted for less than 5% of total lending to other economic sectors (Tyson, 2016).

Otieno (2020) found that dairy farmers in Kenya accessed financial assistance from self-help groups (SHGs), commercial banks, and input stores based on factors such as resource availability, ease of access, and other personal reasons that varied by individual and time. Dairy cooperatives also provided credit services to their members, alongside other support services like artificial insemination, feed supply, training sessions, and milk bulking and selling (Van der Lee *et al.*, 2018). These credit services, including inputs and veterinary services, acted as incentives for farmers to sell their milk through cooperatives and improve production (Ton *et al.*, 2016). Repayment of loans was often made from milk delivered to the cooperatives. However, some repayment schemes incentivized farmers to side-sell their milk to external buyers to earn higher prices.

Variables such as education, Farmer-Based Organization (FBO) membership, and the presence of joint guarantors were found to positively and significantly influence access to credit (Assogba *et al.*, 2017). The authors revealed that formal education favored credit access, and FBO membership was a key factor assessed by microfinance institutions. Their results confirmed that social capital, networks, trust, and contract adherence facilitated both access to and repayment of credit. Additionally, the ability of group members to guarantee one another was found to impact credit access. The study also concluded that higher interest rates and lack of collateral hindered credit access.

Mitra and Prodhan (2018) used a probit model to determine credit access among tomato farmers in Bangladesh. Their study revealed that education, training, farmer-owned assets, and output quantity positively and significantly influenced credit access. However, the age of the household head had a negative association with credit access, with marginal effects showing that an increase in age by one year decreased the probability of accessing credit by 1%. The authors reasoned that older farmers were more risk-averse and less willing to take on credit repayment risks. Kimengsi *et al.* (2020) reported similar results, noting that older farmers were more risk-averse and less likely to invest, even if they accessed credit. Contrary to these findings,

Odhiambo (2020) found that age had a U-shaped relationship with credit access in Kenya, where credit access increased once a farmer reached the age of 49.

Using a double hurdle model, Kumar *et al.* (2021) examined institutional credit access among agricultural households. The model involved two stages: the first determined whether a household accessed credit, and the second determined the amount of credit received. Their results showed that asset ownership, education level, gender, age, family size, landholding, livestock ownership, and asset value influenced access to institutional credit. All these variables, except for gender and livestock ownership, also influenced the amount of credit received. Household heads relying on agriculture as their primary occupation received lower credit amounts, and female-headed households received less credit than male-headed households.

Assogba *et al.* (2017) used a binomial logit model to analyze factors influencing credit access among smallholder farmers in North-East Benin. They found that education, literacy, and group membership positively influenced credit access, while loan interest rates, lack of collateral, and lack of a guarantor negatively impacted access. The authors favored the binomial logit model over the probit model for its simplicity and ease of interpreting results, though both models yielded similar results.

Midamba *et al.* (2022) reported that factors such as mobile phone ownership, group membership, access to extension services, market distance, and farm size significantly increased the likelihood of accessing credit in Uganda. They utilized a binary logit model to analyze the determinants of credit access.

Handio and Jiang (2018) used probit regression to analyze the determinants of credit constraints in Pakistan. Their findings indicated that factors such as distance to banks, interest rates, time lags, land size, loan procedures, and operational holdings significantly influenced access to credit. The study recommended distributing agricultural loans to younger, educated generations to facilitate the adoption of new technologies. In this study, we focused on the choice of milk marketing outlets as an independent variable and its influence on farmers' ability to participate in the credit market as the dependent variable.

2.5. Effect of choice of marketing outlets on smallholder dairy farmers' income

Deciding on the choice of marketing outlet by smallholder dairy farmers is one of the strategies for increasing income. Findings by Kiprotich *et al.* (2017) using Propensity Score

Matching revealed that selling milk through the cooling centers compared to other marketing outlets increased the household's income per lactation period. Smallholder dairy farmers' choice of marketing outlet in Egypt was found to influence income positively (Tarekegn *et al.*, 2017). However, Yolchi (2021) revealed that the choice of the marketing outlet by honey producers did not have any influence on household income. In addition, the study found no price difference among the various honey marketing outlets.

Mojo *et al.* (2017) used both ESR and Propensity Score Matching models to determine the economic impacts of membership in coffee farmer cooperatives in Ethiopia. The authors used the two models because they overcome the selection bias involved in observational studies as compared to the OLS model. Full information maximum Likelihood method of ESR was employed to supplement the PSM result by controlling the unobserved selection bias. The results revealed that cooperative membership had a positive impact on income. Moreover, the ESR estimates confirmed that members of the cooperative performed better economically than if they had not joined. On the other hand, non-members of the cooperative would have performed better than members had they joined the cooperatives.

Kumar *et al.* (2018) used ESR model to determine the impact of cooperative membership on milk yield, net returns and compliance with food safety measures. The results indicated that dairy cooperative membership had a positive and significant on the three outcome variables. The year dummy and share of dairy income had positive impact on members income. The treatment effect results showed that farmers who became members of the cooperatives were less likely to adopt food safety measures compliance. Additionally, non-members of the cooperative societies were more likely to adopt food safety measures compliance had they joined the cooperatives.

To determine the impact of milk marketing channel choice decision on income in Kenya, Ngeno (2018) used Propensity Score Matching. The author argued that the separation of markets by farmers introduced a bias derived from endogenous stratification of market channels thus the PSM was appropriate model for analysis. The farmers selling to commercial milk buyers formed the treatment group while those who did not sell to the same marketing channel formed the control group. The PSM results indicated that the coefficient magnitude of ATT for the entire sample was higher than that of ATU. Furthermore, the ATT effects demonstrated that farmers households selling to commercial milk buyers had higher gross and net income compared to those who did not. Likewise, the ATU effects indicated that farmers who did not sell to the

commercial milk buyers would have had higher net income than those who sold to commercial buyers if they had sold to the commercial milk buyers.

Participating in the dairy hub was found to increased revenues as well as the total household income of dairy farmers in East Africa (Rao *et al.*, 2016). The authors found that farmers participating in pure processing hubs had increased revenue from milk sales due to high prices and low production costs (access to production service and inputs on flexible payment period) compared to those participating in mixed-linkage hubs.

Ngeno (2018) used ESR model to determine the effects of hub participation on farmers' yield and net incomes. The author found that participation in the hub increased farmers' net income by 45% and milk yield by 32%, respectively. Variables that positively and significantly influenced the selection of the dairy hub included education level, access to extension services, access to credit and herd size. The distance to the hub, off-farm income, and household size negatively and significantly influenced hub selection. These results were similar to those (Ma, 2022) that found that agri-value chain participation increased farmers' income. The latter author also revealed that education, household size and farm size were positive and significant determinants of agri-value chain participation and household income.

Using the ESR model to determine the impact of participation in milk processing on smallholder dairy farmers' welfare, Musyoki *et al.* (2022) revealed that education, years of experience, access to extension services and credit positively and significantly influenced incomes. The authors argued that years of schooling and access to extension services increased farmers' knowledge of production methods and their ability to adopt better practices. Access to credit services enabled farmers to pay for inputs, artificial insemination and veterinary services. However, cost of fodder was found to have a negative significant impact on farmers' income. The ATT and ATU results negatively and significantly affected household income.

2.6. Theoretical literature review

This study was based on two theories. The random utility theory for the choice of milk market outlet and social capital theory for credit market participation.

2.6.1. Random utility theory

The choice of fresh milk marketing outlets by smallholder dairy farmers was modeled using the Random Utility Theory (RUT), also known as the Random Utility Maximization

(RUM) model, developed by Domencic and McFadden (1975). In microeconomic theory, utility refers to the satisfaction or benefit an individual gains from choosing one alternative over others. The theory assumes that smallholder dairy farmers are rational decision-makers, seeking to maximize their utility (which in this context refers to profit maximization and reduced transaction costs). Their decision on which marketing outlet to select is influenced by a range of socio-economic and institutional factors.

The RUM model is particularly appropriate for modeling discrete choice decisions, where farmers evaluate different marketing outlets. Under this framework, the indirect utility function suggests that a farmer with certain characteristics will associate an average utility level with each available marketing outlet. This allows for a comparison of expected utility gains when participating in different markets or simultaneous markets. The model considers the impact of socio-economic factors on utility maximization.

In this study, the mapped milk marketing outlets included cooperative societies, individual milk buyers and private milk traders. These outlets are not mutually exclusive, meaning that farmers may opt to engage with more than one outlet at any given time. A household i is faced with a decision to choose from various alternative milk marketing outlets ($j = 1,2,3,4,5$) and it is assumed to derive a certain level of utility from each option. As noted by Greene (2012), utility is not directly observable, but the choice made by the household reveals the marketing outlet that provides the highest utility. This decision-making process is driven by the household's aim to maximize utility, balancing factors such as profitability and transaction costs. Equation 1 below shows the decomposition for utility maximization.

$$Y_{ij} = \beta X' + \mu \dots \dots \dots (1)$$

Where Y_{ij}^* is the maximum utility that a household i derives from choosing j th marketing outlet, X' explanatory variables influencing marketing outlet choice, β is the parameter to be estimated and μ is the error term.

2.6.2. Social Capital theory

Social Capital Theory emphasizes the value of social relationships in facilitating access to resources, including credit. According to Putnam *et al.* (1993), social capital refers to the networks, norms, and social trust that foster cooperation for mutual benefit. In the context of

credit access, farmers benefit from these social relations, particularly through organizations like cooperatives.

Cooperatives, as social organizations, provide a platform where members can pool resources, build trust, and establish collective norms that enable easier access to credit. Membership in cooperatives often enhances social trust, allowing individuals to gain access to loans and credit facilities that would otherwise be difficult to obtain individually. These networks also reduce information asymmetry between lenders and borrowers, improving trust and minimizing perceived risks. Moreover, cooperatives serve as guarantors for farmers who might lack conventional collateral, enhancing their credibility to financial institutions.

In essence, social capital plays a pivotal role in enabling farmers to access credit, particularly in rural areas, by leveraging collective support, trust, and shared resources. This dynamic underscores the importance of community-based structures in enhancing financial inclusion.

2.7. Conceptual framework

The effect of choice of milk market outlet on smallholder dairy farmers' credit market participation and incomes was conceptualized in figure 1. It was hypothesized that the choice of milk marketing outlet was influenced by socio-economic, institutional, and market factors. Socio-economic factors such as age, gender, off-farm income, occupation, education, farm size, feeding systems, and breeding types were thought to influence farmers' decisions to select which market outlet to utilize. Institutional factors such as access to credit, association membership and extension services, were conceptualized as influencing market participation by offering support and resources. Additionally, market factors like the price per litre of milk and the distance to collection centres were assumed to shape farmers' market choices based on revenue received and transportation cost.

Moderating factors such as government support and assistance from development organizations were theorized to influence the relationships by improving access to resources and services. The framework further suggested that credit market participation was affected by the chosen milk market outlet and socio-economic factors. Finally, farmers' income was conceptualized as being determined by their market outlet choices and participation in credit markets, with those choosing more favorable outlets and accessing credit expected to achieve higher income levels.

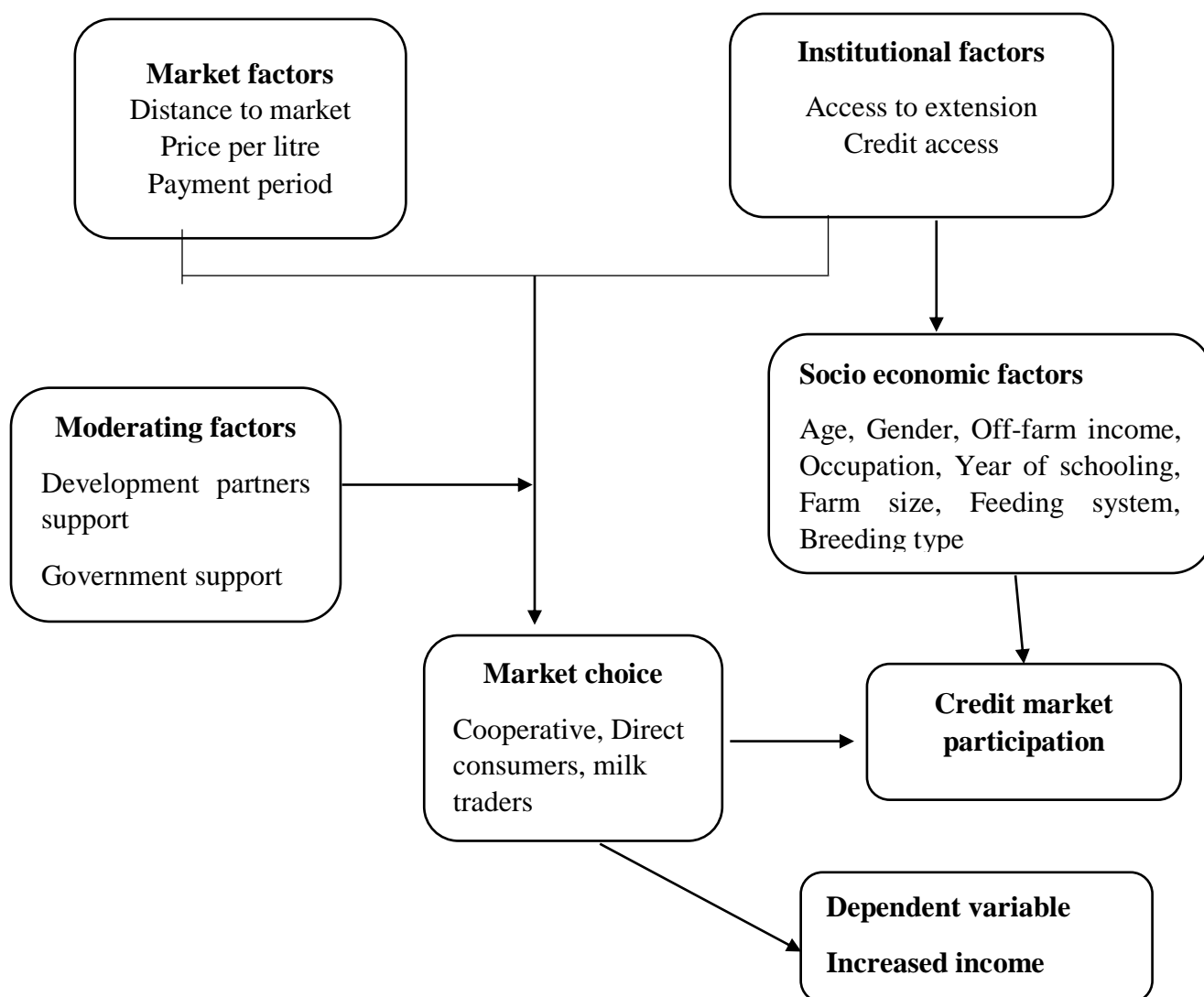


Figure 1: Conceptual Framework

CHAPTER THREE

METHODOLOGY

3.1. Study area

This study will be carried out in Borabu Sub-County in Nyamira County and Rachuonyo South in Homa Bay. In these two counties, milk produced by smallholder dairy farmers is marketed through individual buyers and middlemen alongside formal outlets such as cooperative societies (Osewe, Kharde, and Kipsat 2016; Stirling Consultants Limited 2014). Borabu is the largest sub-county in Nyamira County with an area of 246.9 sq. km (KNBS, 2019). It is located in the northern part of Nyamira county that lies within latitude $0^{\circ} 30'$ and $0^{\circ} 45'$ south and between longitude $34^{\circ} 45'$ and $35^{\circ} 00'$ east and borders Masaba North, Sotik and Trans-Mara sub-counties. The Borabu sub-county has four wards: Esise, Mekenene, Nyansiongo, and Kiabonyoru. It has a population of 73,167 and a population density of 296 per sq. Km (Kenya National Bureau of Statistics, 2019). This area was selected because of the increased dairy farming commercialization. The area was also chosen for Smallholder Dairy Commercialization Programme funded by IFAD from 2005 to 2015. The county's topography is primarily hilly with Kiabonyoru, Nyabisimba, Nkoora, Kemasare hills and the Manga ridge being the most predominant feature. There are two topographical zones in Nyamira County between 1,250 m and 2,100 m. The highlands cover 82% of the county while the remaining 18 are in the upper midland zone. Bimodal, reliable, well-distributed rain patterns are experienced within the county annually. The annual rainfall ranges between 1200 mm-2100 mm per annum while the average daily temperature is 19.4°C with the minimum and maximum temperatures ranging between 10.1°C and 28.7°C , respectively. The area is suitable for both crop and animal production.

According to the CIDP (2018), about 90% of the population in this county depends on agricultural production and marketing as a source of livelihood. The cash crops grown include coffee, tea and pyrethrum, bananas and high-potential horticultural crops. Major food crops include maize, millet, sorghum, potatoes, cassava, and vegetables. The primary livestock bred in the county is dairy farming, beef farming, goat, sheep, fish, rabbit and beekeeping. Nyamira County forms part of the NKCCDFG Sotik milk shed, with dairy cows contributing to 1.9% of the total number of exotic breeds in Kenya (KNB, 2019). The common production system

includes paddocking and strips grazing approaches where animals are allowed to graze freely on natural and or improved pastures and then supplemented with fodder (Wairimu *et al.*, 2021). Intensive zero-grazing is also gaining popularity due to the increase in population size. To improve milk production and marketing within Borabu Sub-County, the Highland creamers milk processing plant was established in 2017 alongside several milk cooling centers for the dairy groups. According to the Borabu Cooperative Union, the active cooperatives include Menyena, Matutu, Mwangori and Manga with about 500 registered members. Figure 2 below shows the map of the study area.

Homa Bay County is located in the Western region of Kenya, along the south shore of Lake Victoria. It lies between latitudes 0 ° 15 South and 0 ° 52 South, and between longitudes 34⁰ East and 35 ° East (Figure 2). The county covers an area of 3152.5 sq. km with a population of 1,131,950 persons (KNBS, 2019). The county's topography is divided mainly into two; lakeshore lowlands and the upland plateau which begins from 1,219 m above sea level. The climatic condition in the county is inland equatorial, and the temperatures range from 17 ° to 25 ° (CIP Homa Bay, 2018).

Homa Bay County has two rainy seasons, with the long rains from late March to June ranging from 800mm-1800m. The short rains are experienced from start in August to December ranging from 250 mm-700 mm. Agriculture is a major source of livelihood for many households resulting in increased income and food security. Agricultural production activities vary in the different agro-ecological zones. The main food crops produced in the county are maize, beans, green grams, sorghum, finger millet, kales, cassava, sweet potatoes and cowpeas. It is estimated that 80% of farmers grow beans and maize (MoALF, 2016). Livestock breeds reared for milk and meat production consist of East African zebu, dairy goats and exotic dairy cows.

The number of local zebu breeds in Homa Bay is still high at 90,756 while the number of crosses is 3005 (Auma *et al.*2017). However, despite a large number of local zebus, around 45% of them are mature cows and 35% are estimated to be in milk production throughout the year with an average of 1.5 litres a day. Through the implementation of the Accelerated Value Chain Development Program, dairy technology including AI and fodder production has led to increased milk production and productivity in South Rachuonyo.

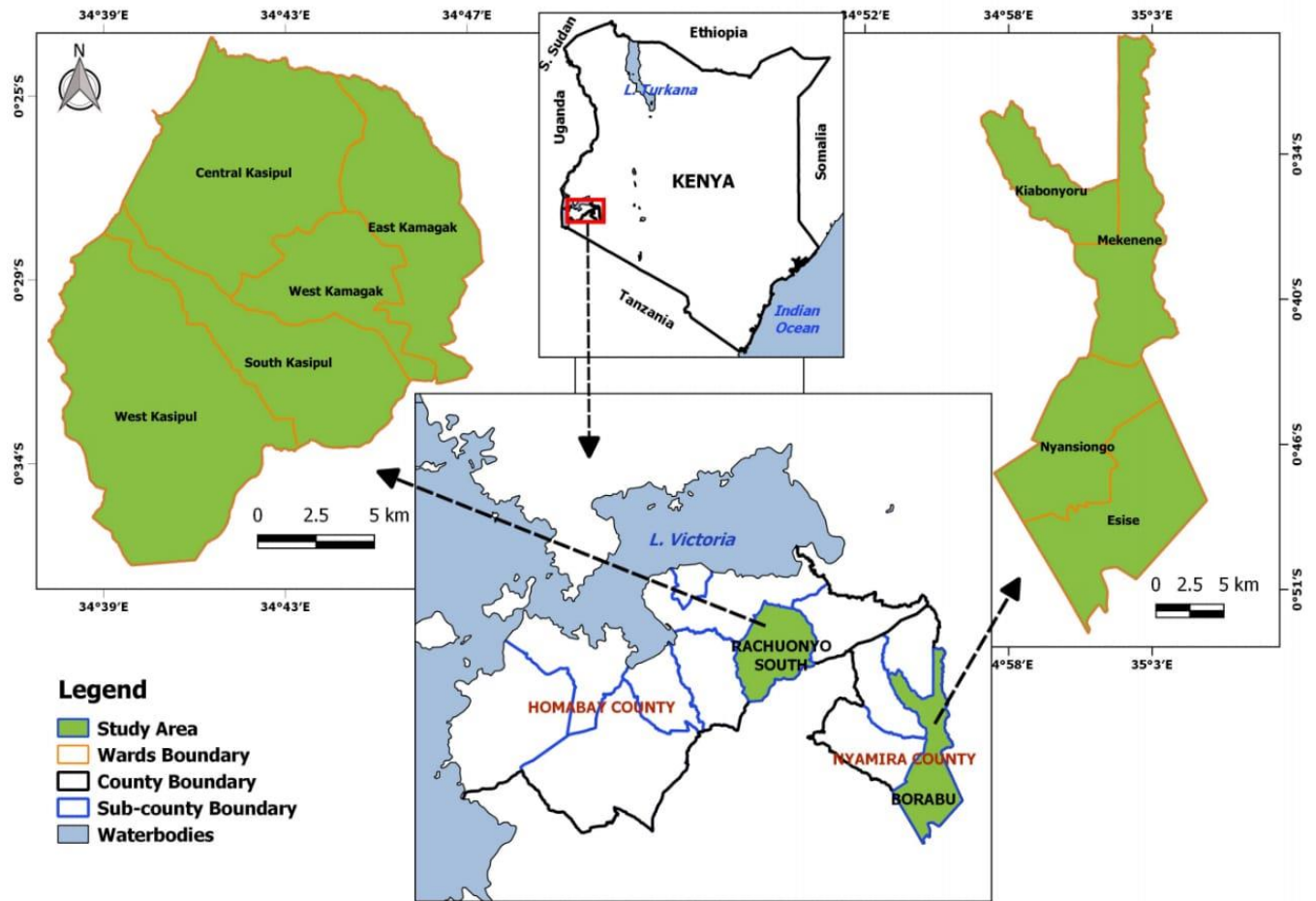


Figure 2: Map of Borabu and South Rachuonyo Sub-Countries

3.2. Research design

This study will employ a descriptive survey research design. This is because it will enable data to be collected using questionnaires and interviews from sample units selected from a population (Orotho, 2003). Collecting data from the entire population is costly and time-consuming thus using a sample population for inference is appropriate. In addition, a descriptive research design is appropriate for the collection of data on people's attitudes, habits and/or other possible behaviours such as choices (Orodho & Kombo, 2005)

3.3. Sample Size Determination

The population from which the sample will be drawn consists of households who are registered members of the dairy cooperatives from Borabu and Rachuonyo South Sub-Countries. The sample size was determined using Yamane's (1967) formula.

$$n = \frac{N}{1+N(e^2)}$$

$$= \frac{906}{1 + 906 (0.05^2)}$$

$$n = 277$$

Where: n =Desired sample size, e = Margin of error and N = the population of registered cooperative members

3.4. Sampling Procedure

A multistage sampling technique will be used in this study. The first stage is the purposive selection of two sub-counties (Borabu and Rachuonyo South) because of increasing in dairy farming commercialization and the existence of Private-Public Partnerships promoting dairy farming. The second stage will involve the identification of active cooperatives with cooling facilities (Borabu cooperative union and Kasbondo dairy cooperative). Respondents will be drawn from the sub-counties using a simple random procedure. The sample size will be divided in proportion based on the registered number of cooperative members over the past year in the two sub-counties as shown in Table 1 below.

Table 1. Sample Size Distribution

Sub-County	Cooperative members	Proportion	Sample proportion
Borabu	501	0.553	153
Rachuonyo South	405	0.447	124
Total	906		277

3.5. Data Collection Procedure

Primary data was collected from smallholder dairy farmers who were members of dairy cooperatives in Borabu and Rachuonyo South using a semi-structured questionnaire. Data collection was conducted electronically on Android smartphones through face-to-face interviews. The smartphones were pre-loaded with the survey questionnaire, which was designed in Open Data Kit (ODK). The ODK application included built-in range and consistency checks to ensure the quality of the data collected. A team of trained enumerators facilitated the data collection

process. The data was downloaded from the ODK Collect tool as do-files and cleaned using SPSS. After data cleaning, both Stata and SPSS software were used to analyze the research objectives.

3.6 Reliability of the instruments

A pretest was conducted to assess the reliability and functionality of the system in Kisumu County at Osiepe Dairy. The pretest involved a team of nine enumerators, who were tasked with actual data collection process. This exercise allowed for the identification and correction of potential issues related to the survey tool, ensuring that the system would perform effectively during the main survey. The pretest also provided an opportunity to train the enumerators and ensure they were familiar with the ODK platform, further contributing to the accuracy and efficiency of the data collection process.

3.7 Data Analysis

Data analysis was conducted using SPSS version 22.0 and STATA 14 software, incorporating both descriptive and inferential statistics. Descriptive statistics included means, minimum and maximum values, frequencies, percentages, and standard deviations to summarize the characteristics of the data.

For inferential statistics, both the chi-square (χ^2) test and t-test were performed. The chi-square test was used to assess relationships between categorical variables, while the t-test was employed to compare significant differences between farmers in Nyamira and Homa Bay. In addition, Excel was utilized for generating graphs and performing mathematical calculations related to incomes and costs.

3.8 Analytical framework

3.8.1. Objective one: To determine factors that influence the choice of milk marketing outlets by smallholder dairy farmers

A combination of descriptive statistics and an econometric model was used to analyze this objective. Means, minimum and maximum values, percentages and standard deviation will be used to describe socio-economic, institutional and market characteristics. Inferential statistics (t-test and chi-square) were used to make a comparison between farmers selling to cooperatives and other milk marketing outlets. Descriptive statistics do not show the marginal effects of the factors influencing farmers' decisions in choosing milk marketing outlets. A Multivariate Probit

model was used to determine the factors influencing the choice of marketing outlets by smallholder dairy farmers. According to Greene (2012), using Binary Logit or Probit restricts the choice of market outlet to only two and will produce biased estimates of choice probabilities as well as incorrect standard errors for the parameters.

An alternative model to analyze this objective is the Multinomial Logit. Studies by Berem *et al.* (2015) and Ongwech *et al.* (2021) used MNL to determine factors influencing the choice of marketing outlets. However, the MNL model is only appropriate when households choose only one marketing outlet from a series of mutually exclusive markets. MVP is suitable for this study because it simultaneously captures the influence of the set of explanatory variables on each of the different outlet choices while allowing for the potential correlations between unobserved disturbances and the relationships between the choices of different market outlets (Greene, 2012).

Smallholder dairy farmers' choice of fresh milk marketing outlets was anchored on the random utility theory, also known as the random utility maximization (RUM) model by Domencic and McFadden (1975). The MVP model assumes that a household i a decision on the choice of marketing outlet, considering non-dominantly exclusive alternatives that constitute K^{th} a set of milk marketing outlets. The choice of outlets may differ depending on the utility that the household gets from the different sets. Equation 1 shows the farmer the choice of K^{th} marketing outlet

$$\gamma^*_{ik} = X_i\beta_k + \varepsilon_i \dots\dots\dots(1)$$

Where; $i = 1, 2, \dots, n$, k is the choice of market γ_1 cooperatives, γ_2 private milk traders, γ_3 direct consumers, γ^*_{ik} is the latent variable showing farmer's utility, β are vectors of simulated maximum likelihood (SML) parameters to be estimated, X_i is the vector of explanatory variables determining the respective marketing outlet choice variable and ε_i is the error term. Equation 1 can be translated into an observed binary outcome Equation for each marketing outlet choice as shown by equation 2

$$\left. \begin{aligned} \gamma_{i1} &= \beta_1\chi_{k1} + \varepsilon_{i1} \\ \gamma_{i2} &= \beta_2\chi_{k2} + \varepsilon_{i2} \\ \gamma_{i3} &= \beta_3\chi_{k3} + \varepsilon_{i3} \end{aligned} \right\} \dots\dots\dots(2)$$

Where γ_{i1} , γ_{i2} , γ_{i3} are the marketing outlet for consumers, private milk traders and cooperatives taking the value of 1 when farmer i choose consumers, private milk traders and cooperatives respectively and 0 otherwise, χ_{k1} , χ_{k2} and χ_{k3} are vectors of explanatory variables ε_{i1} , ε_{i2} and ε_{i3} are the error terms

In a multivariate probit model, the error terms of the marketing outlets' choices follow a joint multivariate normal distribution (MVN) with zero conditional mean and variance normalized to unity and asymmetric covariance matrix shown below

$$\Omega = \begin{bmatrix} 1 & \rho_{y_1y_2} & \rho_{y_1y_3} \\ \rho_{y_2y_1} & 1 & \rho_{y_2y_3} \\ \rho_{y_3y_1} & \rho_{y_3y_2} & 1 \end{bmatrix} \dots\dots\dots (3)$$

In Equation 3, the diagonal represents the unobserved correlation between the stochastic components of different outlets. The specification with non-zero off-diagonal elements allow for correlation across disturbance terms of several latent equations, representing unobserved characteristics that affect the choice of alternative outlets. Choosing the right market channel is a complex decision influenced by various factors. To analyze market outlet choices, household socio-economic characteristics, market-related factors, and institutional factors were considered. These variables were drawn from prior research and have been used in previous studies to understand the determinants of market selection (Cheelo *et al.*, 2021; Kurgat *et al.*, 2023). Smallholder day farmers' choice of milk marketing outlet can be demonstrated using the equation below 4. Table 2 below describes the variables used in the MVP.

$$Y_1 = \beta_0 + \beta_1 age + \beta_2 Exp + \beta_3 Hsize + \beta_4 tdist + \beta_5 lact\ cow + \beta_6 hhhgender + \beta_7 farmsize + \beta_8 Yrschl + \beta_9 off-farm\ in + \beta_{10} CredAcc + \beta_{11} aveprice + \beta_{12} AccExtension$$

Table 2. Variables used for the Multivariate Probit Model

Variable	Description	Measurement	Expected sign
Dependent			
γ_i	Choice of market outlet γ_{i1} consumer =1 or 0 otherwise, γ_{i2} private milk trader =1 or 0 otherwise, γ_{i3} cooperatives=1 or 0 otherwise	Categorical	+/-
Independent			
Age	Age of the household head	Continuous	+/-
Experience	Years of experience in dairy farming	Continuous	+/-
Hsize	Household size in number	Continuous	+/-
Tbdist	Distance to the nearest market in Km	Continuous	+/-
Lactating_cows	Number of lactating cows	Continuous	+/-
Hhhgender	Household head gender Dummy 1=male 0 =female	Dummy	+/-
Prc/Ltr	Price per Litre of milk in Ksh	Continuous	+/-
Off-farmincome	Off farm income 1=yes,0 =no	Dummy	+/-
Farmsize	Total Land size in acres	Continuous	+/-
Yrschl	Years of schooling	Continuous	+/-
AccExtension	Access to extension services 1=yes,0 no	Dummy	+/-
CredAcc	Access to credit 1=yes,0 =no	Dummy	+/-

3.8.2. Objective two: To evaluate the effects of selling to the cooperatives on farmers' credit market participation- borrowing and repayment

To analyze the factors affecting credit market participation among smallholder dairy farmers, a Binary Logit model was employed. This method is particularly suitable for evaluating

dichotomous outcomes, such as whether a farmer participates in the credit market (represented as 1) or not (represented as 0). The use of non-linear specifications, including both Probit and Logit models, is appropriate due to the limitations associated with the Linear Probability Model (LPM).

The analysis of models that incorporate dummy variables is based on the assumption of latent (unobserved) variables, which can only be represented as binary outcomes (Maddala, 2001). While both the Probit and Logit models can yield similar results under certain conditions, the Logit model is often preferred due to its flexibility and straightforward mathematical interpretation. Specifically, the conditional probability P approaches 0 or 1 more gradually in the Logit model than in the Probit model, which helps mitigate the impact of outliers and leads to better statistical management (Gujarati, 2003; Miller *et al.*, 2022). The Logit model specification is shown below:

$$= P_i = E\left(Y = \beta \frac{1}{X_i}\right) = \frac{1}{1 + e^{-Z_i}} \dots \dots \dots (4)$$

Where: $Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k$

P_i is the probability that a household participates in the credit market.

Y is the binary outcome variable, with 1 indicating participation and 0 indicating non-participation.

β_i =Coefficient of explanatory variables to be estimated

X_i = i^{th} explanatory variable

K =number of explanatory variables included in the model

From Equation 4 we generate the odds ratio shown in equation 5.

Therefore, the odds ratio $\left[\frac{P_i}{1-P_i}\right] = \frac{1+e^{Z_i}}{1+e^{-Z_i}} = e^{Z_i} \dots \dots \dots (5)$

Where P_i to the probability of a house participating in the credit market while (1-Pi) is non-participation.

The odds ratio illustrates the relationship between the probability of participation and the probability of non-participation. By taking the natural logarithm of the odds ratio, we obtain:

Taking natural logarithms of $\left[\frac{P_i}{1-P_i}\right] = e^{Z_i}$ we get

$$\ln \left[\frac{P_i}{1-P_i}\right] = Z_i = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 \dots \beta_k\chi_k + \mu \dots\dots\dots (6)$$

Where P_i is the probability that a household participates in the credit market.

$1 - P_i$ probability of non -participation in credit market

β_i =Coefficient of explanatory variables to be estimated

X_i = i^{th} explanatory variable

K =number of explanatory variables included in the model

The marginal effect (ME) of each explanatory variable on the probability of credit market participation can be calculated as follows:

$$ME = \chi_k = P_r \left(Y = \frac{1}{\chi}, \chi_k = 1 \right) - P_r \left(Y = \frac{1}{\chi}, \chi_k = 0 \right) \dots\dots\dots (7)$$

Where $P_r \left(Y = \frac{1}{\chi}, \chi_k = 1 \right)$ denotes the predicted probability that Y equals 1 (participation in credit market), when k^{th} is explanatory variables is set to one (1 unit increase). While $\left(Y = \frac{1}{\chi}, \chi_k = 0 \right)$ This denotes the predicted probability that Y equals 1 when the k^{th} explanatory variable is set to 0.

The marginal effect provides insight into how a one-unit change in an explanatory variable affects the probability of participating in the credit market. For instance, if the marginal effect of age is positive, it suggests that as farmers age, their likelihood of participating in the credit market increases. Conversely, a negative marginal effect would indicate that an increase in that variable decreases the probability of participation. Understanding the marginal effects is crucial for interpreting the results of the Logit model, as they offer a more nuanced view of how each factor influences credit market participation among smallholder dairy farmers.

Previous studies have identified various factors that influence farmers' access to credit. For instance, Assogba *et al.* (2017), Handio and Jiang (2018) and Midamba *et al.* (2022) found that socio-economic, institutional, and market-related factors play a significant role in determining credit accessibility for farmers. Building on these findings, this study explores the

determinants of credit participation among dairy farmers. The model specified in this research includes a range of explanatory variables as expressed below and shown on table 3.

$$Z_i = \beta_0 + \beta_1 Age + \beta_2 hhGender + \beta_3 Chmrk + \beta_4 assstMmbr + \beta_5 formal - education + \beta_6 off - frm + \beta_7 ExrnAccess + \beta_8 farmsize + \beta_9 Feedsystem + \beta_{10} AmntAcc$$

Table 3. Description of variables used in the Logit model and their expected outcome

Variable	Full description of the variable	Type	Expected outcome
Age	< 35 years=1, 0 otherwise	Dummy	+/-
Hhgender	Household head gender 1= male 0 = female	Dummy	+/-
Chmrkt	Choice of market outlet 1= cooperative, 0 otherwise	Dummy	+/-
AsstnMmbr	Association membership 1= yes, 0= otherwise	Dummy	+/-
formal_education	Formal education 1=Yes, 0 no	Dummy	+/-
Amnt Acc	Amount of credit received by a farmer in form of cash or input credit	Continuous	+/-
Off-frm income	Access to off-farm income 1=yes, 0 =no	Dummy	+/-
Farmsize	< 1 acre=1; otherwise	Dummy	+/-
fdng_sytm	Feeding system 1=intensive, 0= otherwise	Dummy	+/-

3.8.3. To determine the effect of the choice of fresh milk marketing outlets on smallholder dairy farmers' income.

This study used endogenous Switching Regression to achieve this objective with income effect from market outlet choice as the result variable. A farmer deciding on whether to sell to the cooperatives or not brings a selection bias therefore, Ordinary Least Square (OLS) would result in inconsistent estimates.

Propensity Score Matching, double in difference (DID), instrumental variables (IV) and Heckman selection Correction Model can also be used to evaluate income impact. PSM compares the average effect of participants (treats) and non-participants (controls) of a project based on observed factors. It controls for selection bias by comparing the 'treats' and 'controls' are similar in observable characteristics (Dehejia & Wahba, 2002). However, PSM does not consider unobserved characteristics such as motivation, skills and risk traits.

Double in difference method compares the difference before and after intervention for both the control and treatment separately but considers selection bias. For use IV, it is difficult to find a variable that highly correlates with the exogenous variable but their error terms are not correlated (Woodridge, 2002). This study adopted ESR to overcome the weakness of all the alternative methods.

ESR model accounts for the unobserved characteristics that influence both the market choices and are likely to correlate with unobserved factors influencing farmers' income. Unobserved factors are likely to influence the choice of milk market outlets. Ignoring the endogeneity problem associated with market outlet choice could have resulted in unbiased estimates.

The ESR model is a two-stage framework process. In the first stage, farmers' decision to sell to the market outlet is modelled using a Probit model; in the second stage, the impact of the choice on income is evaluated. The household's choice of milk marketing outlet is assumed to be motivated by the maximum utility (expected income benefits) from participation. Therefore, a household i decisions to sell to a cooperative society can be represented by equation 8

$$P_i^* = \gamma Z_i + \mu_i \dots\dots\dots (8)$$

Where P_i^* is the latent variable indicating the choice of cooperative, Z_i is a vector of exogenous variables influencing the choice of cooperatives, γ is a vector of parameters to be estimated (income) and μ_i is the random error term associated with the choice of cooperatives. Equation 5 is also known as the selection equation.

From equation 8, we can generate two separate regimes showing the income levels for farmers who participated in cooperative marketing and those who did not (non-participants). This forms the second stage of the ESR model as shown in equations 6 and 7 (Tambo & Wünsch 2017). Full information maximum likelihood (FIML) is used to simultaneously estimate the selection equation (8) and the outcome equations 6 and 7 (Lokshin & Sajaia, 2004).

Regime 1; (cooperative participants) $\gamma_{1i} = \beta_1 X_{1i} + \varepsilon_{1i}$ if $P_i = 1$(9)

Regime 2; (non-participants) $\gamma_{2i} = \beta_2 X_{2i} + \varepsilon_{2i}$ if $P_i = 0$(10)

where Y_{1i} and Y_{2i} are latent variables (household income level) that define observed income levels, $P_i = 1$ or $P_i = 0$ (whether the household sold to the cooperative or not). x is a vector of exogenous variables determining the level of income, β are the vector of parameters to be estimated while ε_{1i} and ε_{2i} are the disturbance terms. x contains factors affecting income levels that are observable only. The error term from the selection and outcome equations (9 and 10) are assumed to be normally distributed with zero mean and a covariance matrix as shown in equation 8. The covariance between ε_{1i} and ε_{2i} is indicated as dots because Y_{1i} and Y_{2i} are not simultaneously determined (Maddala, 1983).

$$Cov(\mu, \varepsilon_1, \varepsilon_2) = \begin{pmatrix} \sigma_\mu^2 & \sigma_{\mu\varepsilon_1} & \sigma_{\mu\varepsilon_2} \\ \sigma_{\mu\varepsilon_1} & \sigma_{\varepsilon_1}^2 & . \\ \sigma_{\mu\varepsilon_2} & . & \sigma_{\varepsilon_2}^2 \end{pmatrix} \dots\dots\dots(11)$$

Where σ_μ^2 is the variance of the error term in the selection equation, $\sigma_{\varepsilon_1}^2$ and $\sigma_{\varepsilon_2}^2$ show the variances of the error terms in the outcome equations, $\sigma_{\mu\varepsilon_1}$ and $\sigma_{\mu\varepsilon_2}$ are covariance of the error terms between the selection equation and that of the outcome equations (Maddala, 1986).

The error term σ_{μ}^2 , ε_1 and ε_2 according to Lee (1978), is assumed to be non-zero. According to Johnson and Kotz (1970) values of the error terms from equation 11 can be truncated as shown below

$$Y_{1i} = \beta_1 \chi_{1i} + \sigma_{\mu \varepsilon_1} \left[\frac{\phi(\hat{P})}{\phi(\hat{P})} \right] + \varepsilon_{1i} = \sigma_{\mu_1} \lambda_{i1} \dots \dots \dots 12$$

$$Y_{2i} = \beta_2 \chi_{2i} - \sigma_{\mu \varepsilon_2} \left[\frac{\phi(\hat{P})}{1-\phi(\hat{P})} \right] + \varepsilon_{2i} = \sigma_{\mu_2} \lambda_{2i} \dots \dots \dots 13$$

Where $\phi(\cdot)$ is the standard normal probability density function, $\Phi(\cdot)$ is the standard normal cumulative function $\frac{\phi(\hat{P})}{\phi(\hat{P})}$ and $-\frac{\phi(\hat{P})}{1-\phi(\hat{P})}$ are the inverse Mill's ratio evaluated $\hat{P} = yZi$ the cooperatives' participation. P is the predicted probability of selling to the cooperatives by a household. According to Greene (2012) and Wooldridge (2002), ESR accounts for selection bias by including the inverse mills ratio (λ_{i1} and λ_{2i} for participants and non-participants) to the outcome equations 14 and 15 as shown below

$$Y_{1i} = \beta_1 \chi_{1i} + \sigma_{\mu_1} \lambda_{i1} + \varepsilon_{1i} \dots \dots \dots (14)$$

$$Y_{2i} = \beta_2 \chi_{2i} + \sigma_{\mu_2} \lambda_{2i} + \varepsilon_{2i} \dots \dots \dots (15)$$

Where λ_{i1} and λ_{2i} are the selectivity correction terms used to control for selection bias caused by unobserved attributes, ε_1 and ε_{2i} are the random error terms.

According to Lokshin and Sajaia (2004), for better identification of the ESR model, at least one identification variable other than the ones generated by the non-linearity (λ_{1i} and λ_{2i}) should be added to the selection model. The Identification variable is also known as the instrument variable. The instrument variable should influence the selection equation (8) but not the outcome equations (9 and 10). From previous studies, Mojo *et al.* (2017) used the distance to the nearest town as an instrument variable while (Ngeno 2018) used distance to extension services. In this study, the distance to market and milk payment period were as instrumental variables.

Following Di Falco *et al.* (2011), the ESR model computes four expected outcome equations, consisting of both actual and counterfactual incomes. The actual expected outcomes are the real incomes for participants and non-participants, while the counterfactual outcomes

represent hypothetical scenarios (what participants would have earned had they not participated, and vice versa). The outcome equations are formulated as follows:

$$E(Y_{1i}/P = 1) = \chi_{1i}\beta + \sigma_{\mu_1}\lambda_{1i} \dots \dots \dots (13)$$

$$E(Y_{2i}/P = 0) = \chi_{2i}\beta + \sigma_{\mu_2}\lambda_{2i} \dots \dots \dots (14)$$

$$E(Y_{2i}/P = 1) = \chi_{2i}\beta + \sigma_{\mu_2}\lambda_{2i} \dots \dots \dots (15)$$

$$E(Y_{1i}/P = 0) = \chi_{1i}\beta + \sigma_{\mu_1}\lambda_{1i} \dots \dots \dots (16)$$

Following Di Falco *et al.* (2011) and Heckman *et al.* (2001) we calculate the average effect of the treatment on the treated (ATT) by comparing the incomes of farmers sold to the cooperatives with the counterfactual hypothetical case. The ATT for participation in the cooperative is the difference between equations 13 and 15. The average effect of treatment on untreated (non-participants) (ATU) is the difference between equations (16) and (14). ATU measures the potential benefit non-participants would have gained if they had participated

$$ATT = E(Y_{1i}/P = 1) - E(Y_{2i}/P = 1)$$

$$ATU = E(Y_{1i}/P = 0) - E(Y_{2i}/P = 0)$$

By comparing the ATT and ATU, the model provides insight into how cooperative participation impacts income, both for those who sell to cooperatives and for those who do not. It also highlights the potential benefits non-participants could gain if they joined the cooperative system. The use of the ESR model, along with the instrumental variables, ensures that these effects are accurately captured, while accounting for selection bias. To check for the consistency of the ESR model, ATT can be derived using other impact assessment methods such as Propensity Score Matching (PSM) model and Inverse Probability Weighted Adjusted Regression model.

Table 4 Treatment, heterogeneity and transitional heterogeneity effects

Sub sample	Decision stage		Treatment effects
	Participant	Non-participant	
Participant	a) $E(Y_{1i} / P = 1)$	c) $E(Y_{2i} / P = 1)$	On the treated (ATT)
Non-participant	b) $E(Y_{1i} / P = 0)$	d) $E(Y_{2i} / P = 0)$	On the untreated (ATU)

Heterogeneity			
Effects	BH₁	BH₂	TH

Table 4 illustrates the heterogeneity effects for both cooperative participants and non-participants, with treatment effects derived based on earlier work by (Olwande & Smale, 2014). Where *BH* represented the base heterogeneity for participants in cooperative selling, while *BH2* referred to non-participants. TH indicated transaction heterogeneity, which determined whether income effects were greater or smaller for participants compared to non-participants.

Table 5. Covariates for ESR

Variable	Description	Expected sign
Treatment variable		
Participants	1= cooperative 0 otherwise	
Outcome variable	Annual income in Kenyan shillings	
Independent variable		
Age	Age of household head (years)	+/-
hhgender	Gender of household head male =1 female =0	+/-
Yrschl	Years of schooling	+/-
Exp	Dairy experience in years	+/-
Extension acc	Extension services access (yes = 1, no= 0)	+/-
CrdAcc	Access to credit	+/-
Prc/Ltr	Price per litre of milk	+/-
Hrdsize	Herd size	+/-
Offfarmincome	Access to off-farm income (1=yes,0 No)	+/-

H/size	Household size	+/-
Paymthd	Payment duration (daily=1, 0 otherwise)	+/-
DistMrk	Distance to the nearest market centre	+/-
AI Breeding	1=yes 0 = no	

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Overview

This chapter presents the results and discussion of the findings regarding the impact of fresh milk marketing choices on the livelihoods of smallholder dairy farmers in Kenya. The findings are organized into sections corresponding to the specific objectives of the study. The first section provides a summary of descriptive statistics, followed by the results of the Multivariate Probit analysis and post-estimation assessments. The second section focuses on the results obtained from the Binary Logit model, while the final section discusses the Full Information Maximum Likelihood (FIML) Endogenous Switching Regression analysis concerning income effects.

4.2. Descriptive statistics

4.2.1. Descriptive statistics of Farm, Farmer and Market Characteristics in Nyamira and Homa Bay

Descriptive statistics results for continuous variables are presented in Tables 6. The mean age of household heads was 57 years. This implies that most farmers are elderly. The minimum age for of the farmers in the study was 19 years and maximum age 95 years old. In terms of farming experience, Nyamira farmers had slightly more years of experience (16.98 years) compared to Homa Bay (15.74 years), but the differences were not statistically significant.

The average household size for the farmers in the study was 5 which exceeded the average household size in Kenya, standing at 3.9 members (KNBS, 2019). The household size for farmers in Nyamira was 5 while in Homa Bay 6. The largest household had 11 members while the smallest one had only one person. A statistical difference existed in the household size at 1% level of significance. The household size was used to measure labour supply for dairy farming. The volume of fresh milk sold by farmers were statistically different at 1% level of significance. Farmers in Nyamira sold an average of 5.9 litres of fresh milk daily while those in Homa Bay sold 1.53 litres. The minimum volume of milk sold by the all the farmers surveyed was 0.5 litres while the maximum was 44 litres.

Regarding years of schooling, the combined mean was 11 years of schooling showing that most of the farmers had completed primary school. The minimum years of schooling was 0 indicating that there were farmers who never attended any schooling. The maximum years of

schooling was 16 showing that the most learned farmers had completed four years college education. Farmers in Nyamira had more years of schooling (11.75 years) compared to those in Homa Bay (9.58 years), with the t-test result showing a statistically significant differences in the mean. Similarly, farm sizes are larger in Nyamira (5.23 acres) than in Homa Bay (3.24 acres), and this difference is also significant at the 1% level

Table 6. Descriptives of Farm, Farmer, and Market Characteristics in Nyamira and Homa Bay

Variable	Combined (n=277)				Nyamira (n=153)				Homa Bay(n=124)				t-test
	Mea n	Std	Mi n	ma x	Mean	Std	min	Max	Mea n	Std	min	max	
Age (years)	57.8	13.8	19	95	57.5	13	35	95	58.2	14.0	19	87	4.0
Experi ence (years)	16.4	0.70	1	58	17.0	1.0	1	58	15.7	1.0	1	50	1.6
Househol d size	5.29	0.13	1	11	4.83	0.1	1	10	5.87	0.2	1	11	4.1***
Milk sold	4.32	0.41	0.5	44	5.90	0.5	0.5	44	1.53	0.4	0.3	24.6	-5.5***
Years of schooling	10.7	0.27	0	16	11.75	0.3	0	16	9.58	0.4	0	16	-4.0***
Farm size (acres)	4.33	0.25	0.2	12	5.23	0.4	0.2	12.1	3.24	0.2	0.1	6	-4.0***

Note: ***, **, * denote statistical significance at 1%,5% and 10% levels respectively.

'Min' denotes the minimum, 'Max' denotes the maximum, and 'Std' denotes the standard deviation

Table 7 represent the results for descriptive statistics for categorical data. 75 % of the household heads surveyed were male -headed. Off-farm income was more prevalent in Homa Bay, with 29.84% of farmers engaging in additional income-generating activities outside of farming, compared to only 18.3% in Nyamira. This difference is statistically significant, suggesting that farmers in Homa Bay may diversify their income sources more actively than their counterparts in Nyamira.

Table 7. Descriptive characteristics of farm, farmer and market for categorical variable

Variables		Combine (n=277)		Nyamira (n=153)		Homa Bay (n=124)		Chi q
		freq	%	Freq	%	Fre	%	
Gender	Male	210	75.81	120	78.43	90	72.58	0.258
	Female	67	34.19	33	21.57	34	27.42	
Off-farm income	Yes	65	23.47	28	18.3	37	29.84	5.0770* *
	No	212	76.53	125	81.7	87	70.16	
Credit market participation	Yes %	103	37.18	53	34.64	50	40.32	0.331
	No	174	62.82	100	65.36	74	59.68	
Extension access	Yes	160	57.76	98	64.05	62	50.0	5.54**
	No	117	42.24	55	35.95	62	50.0	
Association membership	Yes	127	48.85	73	47.71	54	43.55	0.4783
	no	150	54.15	80	52.29	70	56.45	

Note: *** and ** denotes statistical significance at 1% and 5% level respectively. Freq. shows frequency, % percentages

Credit participation was very low in the study area. Only 37.18% of all the farmers participated in the credit market. However, participation in Homa Bay was slightly higher than

in Nyamira 34.64%. Access to extension services, which is crucial for improving agricultural practices, was more frequent in Nyamira (64.05%) compared to Homa Bay (50%). The significant difference in extension access could reflect better outreach or support systems in Nyamira. Lastly, nearly half of the farmers (48.85%) reported being members of associations, with no significant regional differences between Nyamira and Homa Bay in terms of association membership.

4.2.2 Intended use for the credit

Table 8 illustrated the intended purposes for which farmers sought credit, revealing distinct financial priorities among the respondents. The data showed that 51.46% of farmers indicated their primary motivation for acquiring credit was to cover school fees. Approximately 20% of the respondents aimed to channel the acquired credit into business investments, reflecting their aspirations for economic diversification.

Table 8. Intended use of the acquired credit

Intended use	Frequency	Percentage	Cumulative
School fees	53	51.46	51.46
Business investment	20	19.42	70.88
House construction and repair	15	14.56	85.44
Household regular expense	10	9.71	95.15
Farming (crop and livestock)	5	4.85	100
Total	103	100	

Additionally, 14.56% of the farmers sought credit for housing-related activities, such as construction and repairs. However, a comparatively smaller proportion of the farmers expressed an intention to use the credit for enhancing their farming activities, suggesting that agricultural investment was not a major focus for the majority of respondents. This finding may indicate a gap between credit access and investment in farm productivity.

4.2.3. Credit participation by gender of household head

The data on credit participation by gender, as presented in Table 9 below, revealed a difference in credit market participation between male-headed and female-headed households. Among the 103 households that participated in the credit market, 84.47% were male-headed

households, while only 15.53% were female-headed households. However, four households were refused credit due to non-repayment issues related to previous loans.

Table 9. Credit participation by gender

Gender	Frequency	Percentage
Male	87	84.47
Female	16	15.53
Total	103	

4.2.4. Credit amount acquired by farmers

Table 10 present indicated the range and average amounts of credit accessed by farmers. The minimum credit amount acquired was Kenya Shilling 200, while the maximum reached KENYA SHILLING 900,000, highlighting a significant disparity in the amounts borrowed.

Table 10. Credit amount

	Minimum (Kenya Shilling)	Maximum (Kenya Shilling)	Mean (Kenya Shilling)	Std dev (Kenya Shilling)
Credit amount	200	900,000	42,805	85,462.34

Std dev denotes standard deviation

The mean credit amount stood at Kenya Shilling 42,805, suggesting that most farmers accessed relatively small loans compared to the maximum limit. The standard deviation of Kenya Shilling 85,462.34 indicated considerable variability in the credit amounts acquired, implying that while some farmers accessed substantial funds, many others were limited to smaller amounts. This variability might reflect differing financial needs, creditworthiness, or access to financial institutions among the farmers surveyed. Overall, the findings underscored the diverse financial landscapes within which these farmers operated, which could impact their agricultural and economic activities.

4.2.5 Institutions from which credit was acquired

Figure 4 presents the various institutions from which credit was acquired by the smallholder dairy farmers who participated in the credit market. The results showed that 20% of the participants acquired credit from Cooperatives/SACCOs, including dairy cooperative. Commercial banks were the second most common source, used by 18% of the participants, which demonstrates the reliance on formal banking institutions for larger or structured financial needs.

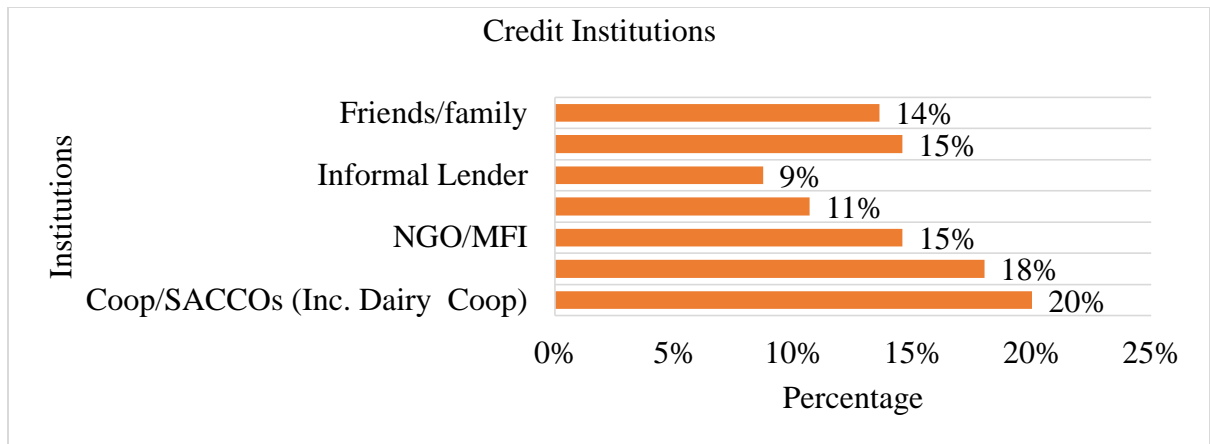


Figure 3. Sources of credit

NGOs and Microfinance Institutions (MFIs), along with mobile apps, each provided credit to 15% of the participants. The use of mobile phone loans showed that farmers were embracing digital platforms in rural areas. Friends and family also played a notable role in informal lending, supporting 14% of farmers. This source of credit can reflect the strength of social network.

Smaller farmer groups provided credit access to 11% of the farmers who acquired credit, emphasizing the role of peer-to-peer lending within organized agricultural groups. Lastly, informal lenders accounted for 9%, showing they were the least favored source, perhaps due to higher interest rates or less formalized credit structures. In addition, friends/family and farmer groups were also sources of credit, with 14% and 11% respectively, demonstrating the importance of informal networks in supporting farmers financially. Informal lenders are the least used credit source, representing only 9%.

4.3. Determinants of fresh milk market outlet choice

4.3.1. Pre-estimation

Pre-estimation tests done before the Multivariate Probit included Variance Inflation Factor, Breusch-Pagan and pairwise correlation. To assess multicollinearity among the variables in the model, the (VIF) was calculated. The analysis revealed a mean VIF of 1.133, with individual VIF values ranging from 1.025 to 1.199. These results indicate that multicollinearity is not a concern in this analysis, as VIF values greater than 10 are typically used as a threshold for identifying significant multicollinearity issues (Hair *et al.*, 2010; O'Brien, 2007). The observed

values suggest that the variables are relatively independent of each other, which is crucial for ensuring the reliability of regression coefficients and interpretations in the model.

Table 11. Variable Inflation Factor

Variables	VIF	1/VIF
Distance to the nearest market centre	1.199	0.834
Farm size	1.193	0.839
Lactating cows	1.173	0.852
Experience	1.151	0.869
Years of schooling	1.131	0.884
Household size	1.06	0.943
Price/ litre	1.025	0.975
Mean VIF	1.133	.

The Additionally, Breusch-Pagan was conducted to test for the presence of heteroskedasticity. The chi-square result from the test was 0.1605, which was greater than 0.05, suggesting no presence of heteroskedasticity

Additionally, Table 11 presents the results of a pairwise correlation analysis among the categorical variable. The correlations reveal weak relationships, with the highest correlation being between household head gender and extension access (0.1656), indicating a modest association. Similarly, household head gender shows a weak positive correlation with credit access (0.1555).

Table 12. Pairwise correlation test for categorical variables

	Household head gender	off-farm income	Credit Access	Extension Access
Household head gender	1			
off-farm income	0.0537	1		
Credit Access	0.1555	0.0438	1	
Extension Access	0.1656	0.0181	0.0984	1

4.3.2. Factors influencing farmer's choice of fresh milk marketing outlets

Figure 4 illustrates the diverse milk value chains in the study area, encompassing both formal and informal markets. In Value Chain I, farmers sell directly to consumers, demonstrating

a straightforward market interaction. Value Chain II involves farmers selling their milk to private milk traders, who can either sell directly to consumers or supply processors that ultimately deliver to end consumers (Value Chain V).

In Value Chain III, farmers sell their milk to cooperatives, which process the milk and sell it to final consumers. Most farmers in Homa Bay typically sell their milk to cooperatives, which add value to the product before distributing it directly to consumers. This approach not only enhances the quality of the milk but also provides more stability in pricing. Conversely, farmers in Borabu primarily market their milk through cooperatives, which supply New KCC (Kenya Cooperative Creameries). New KCC processes the milk and sells it to final consumers, reflecting a structured approach within a formal market framework.

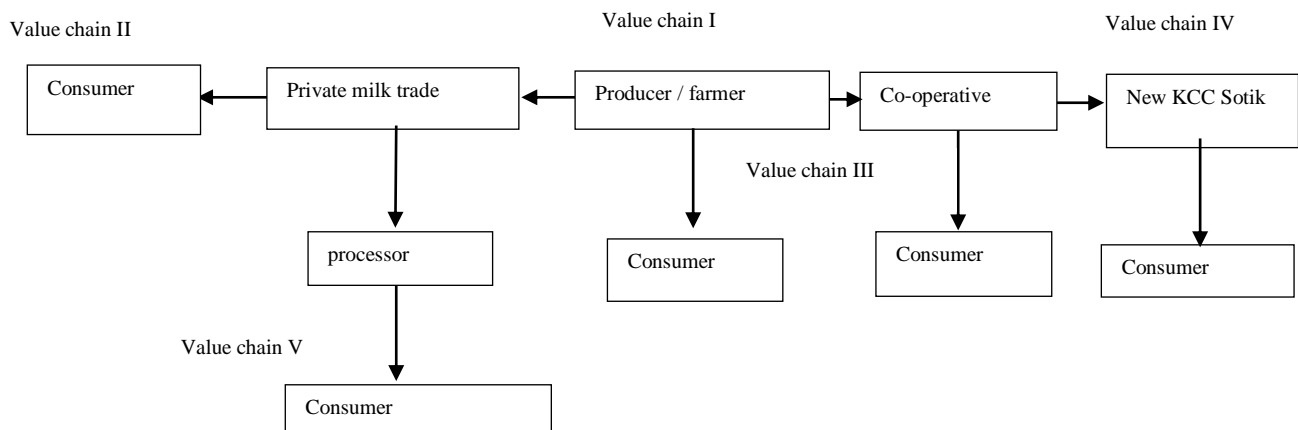


Figure 4. milk value chains

4.3.3 Multivariate probit results

The results presented in table 13 showed that the Wald chi-square of 145.38 was significant at a 1% level of significance showing that the explanatory power of the variables used in the model is statistically acceptable. The results of the likelihood test ratio showed that the likelihood test ratio probability $> \chi^2 = 0.000$ ($\rho_{21} = \rho_{31} = \rho_{32} = 0$) was highly significant at 1% level of significance. This implied that the null hypothesis that the choices of the three milk marketing outlets are independent is rejected.

Table 13. MVP model results for choice of milk marketing outlet

Variables	Consumers (n=116)		Private milk traders (n=15)		Cooperatives (n=160)	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Age	0.091	0.010	0.004	0.014	-0.016*	0.008
Age2	0.001	0.000	0.000	0.001	0.000	0.000
Experience	-0.023*	0.013	-0.042*	0.025	0.025** *	0.009
Household size	-0.064	0.064	-0.035	0.082	-0.058	0.047
Distance to market	-0.116	0.071	0.166	0.112	0.406** *	0.079
Lactating cow	0.083	0.096	0.247*	0.129	0.179*	0.100
Gender (1 = Male; 0 female)	0.197	0.305	0.602	0.492	-0.141	0.234
Land size	-0.048	0.031	-0.077	0.071	-0.0226	0.022
Years of schooling	0.004	0.034	0.016	0.047	0.063**	0.025
Off-farm income (1 = Yes, 0 = No)	-0.195	0.268	-0.423	0.369	-0.348*	0.204
Credit access (1 = Yes, 0 = No)	0.019	0.263	0.081	0.337	0.111	0.199
Price/ litre	0.010***	0.022	-0.000	0.001	0.025** *	0.006
Extension access (1 = Yes, 0 = No)	-0.157	0.286	-0.312	0.363	0.0533	0.197
_cons	-0.461	2.118	-0.913	2.330	-0.525	1.373
ρ 21	-0.415**	0.173				
ρ 31	-0.341**	0.137				
ρ 32	-0.254	0.182				

Number of observations =277 , Wald chi2(36) = 146.36, probability> chi2= 0.000, Log Likelihood test = -226.28, LR of ρ_{21} , ρ_{31} , ρ_{32} =0

Note: ***, **, * denotes statistical significance at 1%,5% and 10% level respectively.

The ρ values (ρ_{ij}) show the correlation between the market outlet choices. ρ_{21} is the correlation between private milk traders and direct consumers, ρ_{31} correlation between cooperative and direct consumers and ρ_{32} correlation between cooperatives and private milk traders. This study's findings indicate that farmers selling to private milk traders were less likely to sell to individual buyers at 5% level of significance. The results also indicated that farmers selling milk to the cooperative societies were less likely to sell to individual buyers at 5% level of significance. This implied that three milk markets in the study area were competitive.

Price was found to have a positive and significant effect on the choice of cooperative and individual buyers at the 1% significance level. This result implies that an increase in the price of milk by one shilling raised the likelihood of selling to individual buyers and cooperative societies. A plausible explanation is that farmers are rational and seek to maximize their returns by selling to outlets that offer higher prices. However, during periods of surplus, farmers may opt for markets that pay lower prices, such as cooperatives, due to market assurance. This finding aligns with earlier studies Cheelo *et al.* (2021) and Kumar *et al.* (2019), which identified both positive and negative significant effects of price on the choice of various milk market outlets. Kurgat *et al.* (2023) found that farmers were indifferent to market outlet choices regarding price per litre; they selected both formal and informal markets but tended to favor the market offering the highest price per litre.

This study established that the age of the household reduces the likelihood of selling to cooperatives at 10% level of significance. This implied that an increase in age by a year reduced the likelihood of choosing cooperatives as a marketing outlet by 1.6%. The coefficient of age squared was not significant. However, Balay (2020), found age square to be significant showing that adaptation of cooperatives as a milk marketing outlet was influenced by age up to a certain age limit. He argued that age can be explained by experience. It can be argued that older people may not have the ability to make a rational decision on income-generating activities while sticking to their old marketing outlets. This result confirms the findings by Sharma (2015) that revealed that an increase in the age of farmers by one year decreased their probability of selling to modern milk markets (cooperatives). The author argued that older farmers were reluctant in

adopting new channels which require the achievement of certain measures as compared to the younger farmers. However, Kiprotich (2017) and Kumar and Parappurathu (2018) established that as farmers age, their likelihood of selling to dairy cooperatives decreases.

Years of experience in dairy farming had a negative and significant effect on the selection of individual milk buyers and private milk traders at 10 % level of significance. This implied that a one-year increase in farming experience reduces the likelihood of farmers selling to individual buyers and private milk traders by 2.3% and 4.2% respectively. However, experience in dairy farming had a positive and significant effect on the choice of cooperatives at 1% level of significance. The possible reason could be that farmers with more experience have acquired enough knowledge about the markets and are able to adopt markets with more benefits. This result conforms to that of Kumar *et al.* (2018) and Tura and Hamo (2018) that indicated that years of experience in dairy farming increased the likelihood of selling to cooperatives societies as compared to direct individual sales.

The distance from the farm to the nearest market had a positive and negative effect on the choice of cooperative and individual buyers at 1% level of significance respectively. An increase in the distance by one kilometer increased the likelihood of selling to the cooperatives by 40% while it reduced that of selling to the individual buyers by 13.1%. This may be a result of cooperatives transporting milk from the farmers to the market at a low cost thus minimizing transaction costs. Jitmun and Kuwornu (2019) found out that farmers far from the marketing centers preferred selling collectively to reduce the cost of transportation.

The number of lactating cows owned by farmers positively and significantly influenced the choice of private milk traders and cooperative marketing outlets at a 10% significance level. Specifically, a unit increase in the number of lactating cows raised the likelihood of selling to private milk traders and cooperatives by 24% and 18%, respectively. The study utilized the number of lactating cows due to its strong correlation with household milk production. Earlier study by Mutura *et al.* (2015), argued that an increase in the number of lactating cows increased farmers' marketable surplus, enabling them to sell to multiple marketing outlets. Similarly, Aderinkola *et al.* (2022) found that an increase in the number of lactating cows led to a higher volume of milk supplied to collection centers in Nigeria. These findings align with those of Ayyano *et al.* (2020) and Ishaq *et al.* (2017), who revealed that farmers with more lactating cows

preferred selling to organized markets, such as cooperative societies, which purchase large volumes of milk at lower transaction costs.

As expected, literate farmers have better access to market information and are more likely to adopt modern milk marketing outlets. The results in Table 10 show that years of schooling had a positive and significant effect on the choice of cooperatives at the 5% significance level. A one-year increase in schooling raised the likelihood of selling to cooperatives by 6.3%. A possible reason for this effect is that more years of schooling may enhance farmers' understanding of market dynamics and improve their ability to access information about better marketing options. This result corroborates studies that have shown years of schooling positively influence the choice of cooperatives (Ketema & Lika, 2023; Kiprotich, 2017; Kumar & Parappurathu, 2018).

Access to off-farm income through non-farm activities negatively influenced the choice of cooperative marketing outlets at 10% level of significance. Farmers with access to other sources of income, aside from dairy farming, were 35% less likely to sell to cooperative societies. A possible explanation is that farmers engaged in off-farm activities did not commercialize milk production or adopt new marketing outlets. Similarly, Kiwanuka and Machethe (2016) found that having more income-generating activities outside the dairy enterprise decreased the likelihood of using modern milk market outlets, such as cooperatives and private milk traders. This result contrasted with the findings of Kurgat *et al.* (2023), who found a positive relationship between off-farm income and formal milk marketing outlet choice.

4.4. Binary logit for credit market participation

Table 14 summarizes the results of the logit model. The log-likelihood ratio test chi2 statistics was 29.04 with a p-value of 0.0012 suggesting that the null hypothesis that the parameter estimates for the model are equal to zero is rejected.

Table 14. binary Logit for credit market participation

Credit market participation	Coef.	Std. Err.	Marginal effect
Age (< 35 years=1; 0 otherwise)	-0.796	1.286	-0.183
Herd size (>5 animals=1;0 otherwise)	-0.112	0.307	-0.026
Gender (1 male; 0=female)	0.944***	0.346	0.197
Extension Access (1=yes; 0 =no)	0.527*	0.292	0.121
Association Membership (1=yes ;0=no)	0.754***	0.274	0.173

Choice of market (1=cooperatives 0)	-0.187	0.288	-0.043
Farm size (1=<1 acres ;0otherwise)	1.029***	0.356	0.236
Off-farm income (1=yes;0 =no)	0.11	0.285	0.025
Formal education (1=yes;0 =no)	-0.28	0.314	-0.064
Feeding system (1=intensive; 0 =otherwise)	-0.474	0.308	-0.109
Constant	-1.716***	0.508	

Log-likelihood = -168.2782, LR chi2(10) = 29.04

Note: ***, **, * denotes statistical significance at 1% ,5% and 10% level respectively.

The results in table 14 confirm that male-headed households are more likely to participate in the credit market. The odds ratio (log of the coefficient) suggests that male-headed households were 3 times more likely to access credit as compared to female-headed households. The marginal effects further indicated that male-headed households were 19.7% more likely to participating in the credit market. The plausible reason for this could be the fact that the males own productive resources as compared to the females. Ahmad *et al.* (2022) found similar results in that more male-headed households received credit compared to females. Contrary to this finding, Gobena and Debebe (2018) revealed that female-headed households had a higher probability of accessing and repaying credit as compared to male

Membership of groups such as Community Based Organizations and merry-go-round groups positively increased the probability of credit market participation by smallholder dairy farmers. The odds ratio shows that farmers who belonged to groups were two times more likely to participate in credit market as compared to those who only belong to the cooperatives. The marginal effect result indicated that group membership increased the probability of credit market participation by 17.41%. A plausible explanation for this finding is that farmers in an association can self-select then based on their ability to repay loans, save and guarantee one another for loans. In addition, memberships can reduce the cost involved in the search for credit source. This result corroborates the findings of Assogba *et al.* (2017) who found a positive effect of group membership on credit access.

Households with access to extension services had a positive and significant effect on credit market participation at the 5% significance level. Specifically, access to extension services increased the probability of participating in the credit market by 12.1%. It could be argued that

farmers receiving regular extension services from various providers gain valuable information about credit options and financial literacy, enabling them to make informed decisions. This finding aligns with the results of Midamba *et al.* (2022), who also identified a positive association between credit market participation and access to extension services.

The coefficient for farm size had a positive and highly significant effect on credit market participation ($p < 0.000$). The odds ratio indicated that farmers with land sizes greater than one acre were three times more likely to receive credit. The marginal effect suggested that an increase in land size by one acre increased the likelihood of participating in the credit market by 23.6%. Since land is a measure of wealth, it can serve as collateral for loans, allowing farmers to secure financing for investments when they lack a personal guarantor. This study's findings are consistent with Kumar *et al.* (2021), who also found a positive and significant association between credit access and farmers' land size. Contrary to this study, Lakhan *et al.* (2020) and Handio and Jiang (2018) found a negative effect between the farm size and credit access by farmers.

4.4.1 Model specification and the Maximum Likelihood Estimate regression for Logit Model

A link test analysis was done to check for model specification errors as shown in table 15 below.

Table 15. Link test for Binary Logit

Credit market participation	Coef.	Std. Err.	P>z
Predicted value (<i>_hat</i>)	1.233651	.3186757	0.000
Predicted value squared (<i>_hatsq</i>)	.2146158	.2168451	0.322
Constant	-.0313466	.1662415	0.850

Log-likelihood = -166.66656, Prob > chi2 = 0.0000, observation 277

The predicted value (*_hat*) shows the explanatory power of the independent variables on credit market participation. On the other hand, the predicted value squared (*_hatsq*) shows the importance of the omitted variables in the model.

The result of the link test showed a Log likelihood test of -166.66656 which was statistically significant at 1 % level of significance (Prob > chi2 = 0.0000). The predicted value (\hat{y}) is significant at 1% level of significance suggesting that we fail to reject the null which states that misspecification errors exist. Hence there was no need to include or omit any variable since the predicted value (\hat{y}) was identical to the Y-dependent variable values. In this study, the loan amount borrowed was highly correlated with the repayment period and credit market participation and hence was omitted from the model.

4.4.2. Test of Heteroscedasticity

Breusch-Pagan test was performed to test for the presence of heteroscedasticity in the model. Heteroscedasticity occurs when the variance of the error terms is not constant across observations in biased estimates. The probability chi-square of 0.1688 from the test was not significant thus indicating no presence of heteroskedasticity in the model.

4.5. To determine the effect of choice of milk marketing outlet choice on smallholder dairy farmers' income

4.5.1. The selection model

The selection model results in Table 16 column 2 can be interpreted as normal Probit coefficients explaining market participation.

Table 16. ESR Results of the effect of choice of milk market on smallholder dairy farmers' income

Variables	Selection model		Choice of cooperative(n=160)		Other market outlets(n=117)	
	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err
Age	-0.004	0.010	0.004	0.005	0.006	0.006
Gender (1 male; 0=female)	-0.165	0.350	-0.172	0.156	-0.055	0.191
Years of schooling	0.063*	0.034	0.065***	0.018	0.042**	0.018
Off-farm income (1=yes; 0=no)	-0.200	0.295	1.006***	0.145	.821***	0.166
Experience	0.020	0.012	0.006	0.006	-0.006	0.007
Household size	0.009	0.074	-0.007	0.035	-0.003	0.035
Credit access (1=yes; 0=no)	0.322	0.301	-0.072	0.142	0.023	0.155

0 =no)						
Extension access	-0.058	0.317	0.181	0.153	0.014	0.154
(1=yes; 0 =no)						
Herd size	0.120***	0.050	0.029	0.023	-0.058**	0.027
Breeding type (1=AI;	0.336	0.298	0.006	0.154	0.136	0.197
0=no)						
Price/litre (KENYA	-0.046*	0.024	0.032***	0.015	.043***	0.012
SHILLING)						
Location Homa Bay	-2.32***	0.456	0.399	0.456	-0.081	0.227
Distance(km)	0.19***	0.087				
Payment period	-	0.301				
(1=monthly ;0	2.029***					
otherwise)						
_cons	1.326	1.067				0.637
					9.265***	
/lns1	-0.40***	0.075				
/lns2	-0.060	0.057				
rho_1	-0.578*	0.245			-0.881	0.0629
rho_2	-	0.154				
	0.614***					
Log likelihood	-381.77					
Likelihood ratio test of independent equations $\chi^2(1)$	12.28***					

Note: ***, **, * denotes statistical significance at 1%,5% and 10% level respectively.

This result conforms with earlier studies by Abdul-Rahaman and Abdulai (2020) and Rao and Qaim (2011) who found that education positively influence the choice of cooperatives. Years of schooling of the household head had a positive and significant effect on participation in cooperative marketing. More educated farmers are likely to adopt improved production and marketing strategies compared to less educated farmers. This finding aligns with earlier studies by Abdul-Rahaman and Abdulai (2020) and Rao and Qaim (2011), who found that education positively influences the choice to participate in cooperatives.

Payment method and price per litre of milk had negative and significant effects on selection of cooperatives. As cooperatives delay in paying farmers for milk delivered from 30 days to more, farmers increase their likelihood of selling to informal markets that pay daily or weekly. A plausible reason for this is that farmers may require cash to meet daily expenses. Wangu *et al.* (2021) revealed that farmers are inclined to brokers who offer a daily cash payment to farmers as compared to processors and dairy cooperatives. The authors further ascertained that those farmers without access to off-farm income chose to sell to outlets that paid cash daily.

Distance to the nearest market had a positive and significant effect on selection of cooperatives. An increase in distance by one km increases the likelihood of selling to the cooperatives by 19%. This may be a result of cooperatives transporting milk from the farmers to the market at a low cost thus minimizing transaction costs. Jitmun and Kuwornu (2019) found out that farmers far from the marketing centers preferred selling collectively to reduce the cost of transportation. Table 16 illustrated that an increase in herd size positively and significantly increased the likelihood of farmers selling to the cooperatives by 12%. Farmers located in Homa Bay county were less likely to sell to the cooperative compared to those in Nyamira county. Moreover, an increase in the price per litre of milk was found to decrease the probability of farmers selecting dairy cooperatives.

4.5.2. Determinants of household income

To test for the presence of endogeneity, the Durbin (1970) chi-squared test and the Wu-Hausman (1973) F-test were conducted before running the Regression (ESR) model. The Durbin chi-squared value was 5.0817 ($p = 0.0159$), while the Wu-Hausman F-value was 5.62 ($p = 0.0185$). Both the Durbin and Wu-Hausman values were significant at the 5% level of significance, thus indicating that the null hypothesis that the choice of milk marketing outlet was exogenous in the model was rejected.

The Sargan test was conducted to assess over-identifying restrictions, following the method outlined by Sargan (1958). The test revealed a p-value of 0.4259, which is greater than 0.05, indicating that the null hypothesis of no over-identifying restrictions should be rejected. Similarly, the Basman test was performed according to the procedure developed by Basman (1960). The test produced a p-value of 0.4382, also greater than 0.05, further supporting the conclusion that used in the null hypothesis of no over-identifying restrictions should be rejected.

The selected instrument variables used in this study were the payment duration and distance to nearest market centre. The instruments used influenced the choice of cooperatives as a marketing outlet but did not influence the farmers' income directly. The coefficients of the instrument variables were jointly significant $F(2,263) p < 0.000$ showing that the instruments used in the model were valid. In addition, the minimum Eigen statistic (62.069) was greater than the critical values. Therefore, the null hypothesis of instruments being weak was rejected.

Table 16 presents the results of the ESR model using the full information maximum likelihood approach (FIML). The Wald Chi-Square statistic was found to be significant at 1 % level of significance thus indicating the goodness of fit of the ESR model. The Wald Chi-Square statistic results also showed that there was an endogeneity problem which was controlled for by the use of the ESR model. The likelihood ratio test of independent equations was highly significant indicating that the null hypothesis (no correlation) between participants in cooperatives and household annual income was rejected. This result shows that the explanatory variables used in the model explained the levels of income as well the differences in income levels between participants and non-participants.

The results showed that level of education significantly affected household incomes for both the participants and non-participants of the cooperatives. An additional year of schooling by the household head increases household income by 6.5% and 4.2% to farmers selling to the cooperatives and other milk marketing outlets respectively. This could be due to the ability of learned farmers to adopt reliable milk marketing outlets. This finding echoed studies by This finding echoed studies by Abdulai and Huffman (2014), Ngeno (2018) and Sharma (2016), who showed who showed that farmers with more years of education were more likely to adopt strategies that increase their incomes due to their knowledge and skills.

As expected, access to other sources of income other than from dairy and crop farming was found to increase farmers' income at 1% level of significance. Access to off-farm income increases household income by 100% and 82% for participants and non-participants of cooperatives respectively. This could be a result of farmers receiving income from other sources to cushion them from crop failures and agricultural commodity price variabilities. Income from non-farm activities could also be used to finance dairy farming for resource-poor households who cannot obtain loans from financial institutions. Twumasi *et al.* (2021) found that off-farm jobs increased household income for members of the cooperative societies

According to African tradition, the number of animals a farmer owns can serve as a proxy for wealth. Ngeno (2018) confirmed that the tropical livestock units owned by participants in the dairy hub contributed to increased net returns. The author argued that farmers with larger herds are typically viewed as wealthier and are better positioned to finance dairy production and absorb the risks involved in farming. Contrary to expectations, however, herd size had a negative and significant effect on the income of non-participants. This may be attributed to the prevalence of local cattle breeds and poor feeding systems adopted by non-participants. In contrast, farmers selling to cooperatives tend to have better access to information on breeding services and improved feed availability. Bidzakin *et al.* (2019) similarly found a negative relationship between farm size and rice gross margins, which they attributed to inefficiencies in land management.

The price per litre of milk was found to be positive and significant at 1% level of significance. This study used price as an independent variable because the two cooperatives offered different prices per liter. Experience in dairy farming had a positive and significant impact on the household income for participants while it did not impact the non-participants. Farmers with more years of experience in dairy farming have accumulated knowledge and skills in production, marketing and enterprise management.

4.5.2 The Treatments Effects on smallholder dairy farmers' income.

Farmers participating in cooperative society marketing formed the treatment group while those that participating in other milk marketing formed the control group. Table 17 summarizes the mean treatment effects and their counterfactual effect on the incomes of dairy farmers. The values in (a) and (b) show the actual log of incomes for participants and non-participants respectively. Participants received higher incomes than non-participants. (c) and (d) are the counterfactual income.

Table 17. Mean treatment effect on farmers' income

Sub-sample		Decision		
		Participants	Non-participants	ATE
Outcome				
Total income	Participants	(a) 12.70	(c) 11.61	ATT = 1.09 ***
	Non-participants	(d) 13.13	(b) 11.93	ATU=1.19 ****

Heterogeneity Effect	BH₁= -0.43	BH₂= -0.32	TH=-0.11
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*** significance at 1%. Note the values are logs of income

ATT demonstrated that participation had a positive and significant effect on household income at 1% level of significance. The mean household income of farmers participating in cooperative marketing would have reduced by 9 % had they not participated (from 12.70 to 11.61). Similarly, ATU results demonstrated a positive and significant effect on non-participants' income 1% level of significance. Non-participants of cooperatives would have increased their income from 11.93 to 13.13 representing a 10% increase if they had participated. These findings are consistent with (Kiprotich 2017; Ngeno 2018; Rao *et al.* 2016) who revealed that formal milk market participation positively impacted farmers' incomes. These findings are consistent with those of Kiprotich (2017), Ngeno (2018) and Rao *et al.* (2016), who revealed that formal milk market participation positively impacted farmers' incomes.

The negative base heterogeneity BH₁ showed that non-participants would earn an increase of 0.43 in their log of income had they participated. Likewise, the negative BH₂ suggested that participants would have reduced their log of income by 0.32 had they not participated. The negative transitional heterogeneity (TH) implies that income effects are greater the non-participants.

4.5.3. Robustness Check

To ensure the reliability and robustness of the ERS model, a thorough robustness check was performed using two advanced statistical techniques: propensity score matching (PSM) and inverse probability weighted regression adjustment (IPWRA). These methods are commonly employed to address potential selection biases and ensure that the estimated treatment effects reflect true causal relationships. The results of the analysis indicated that the average treatment effects of cooperative participation were not only positive but also statistically significant. This finding is illustrated in Table 18, where the estimated average treatment effects on household income show significant values.

Table 18. ATT results using PSM and IPWRA

Outcome	ATT(PSM)	ATT(IPWRA)
Household income	0.716(0.306) **	0.493(0.28) *

Note: Note: **, * denotes statistical significance at 5% and 10% levels respectively. ATT is based on the log of household income.

These findings suggest that participation in cooperatives has a substantial positive impact on household income. The robust nature of these results supports the conclusion that cooperative membership plays a vital role in enhancing the economic well-being of smallholder dairy farmers.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

This study found that smallholder dairy farmers who actively sold milk to cooperatives had better access to extension services and relied more heavily on farming as their main source of income. Key factors influencing cooperative participation, as identified by the Multivariate Probit analysis, included years of experience, education level, price per liter of milk, the number of lactating cows, and access to off-farm income. When examining credit market participation, the logit model indicated that gender, access to extension services, association membership, and land size were significant, with male-headed households having better access to credit. Importantly, the choice of milk marketing outlet did not significantly affect credit access.

Additionally, the study used the Full Information Maximum Likelihood (FIML) endogenous switching regression (ESR) model, which showed that cooperative marketing participation increased household income by 9.4%. Factors such as education, access to off-farm income, the price of milk, and herd size were found to have a significant effect on farmers' income levels.

5.2 Conclusions

- i. Distance to the nearest market center, price per litre, and education were the most significant factors that positively influenced the choice cooperative, as indicated by the multivariate probit model.
- ii. Credit market participation was positively and significantly affected by household head gender (male), association membership, access to extension services and land size.
- iii. The Endogenous Switching Regression (ESR) model showed that payment period negatively influenced the choice of cooperatives, reducing participation.
- iv. Farmers located in Homa Bay were less likely to sell to cooperatives, possibly due to geographic or logistical constraints.
- v. Off-farm income and education positively influenced farmers' income in the study area, indicating that income diversification and higher education levels led to better financial outcomes.

- vi. The treatment effect analysis demonstrated that participation in cooperatives had the potential to significantly increase farmers' income, highlighting the economic benefits of collective marketing and resource access through cooperatives.

5.3 Recommendations

- i. Improve access to collection centers: The government should invest in developing infrastructure such as roads and electricity to minimize transportation costs and enhance access to milk collection centers.
- ii. Stable pricing policies: Cooperatives should implement stable pricing strategies and enhance milk prices through value addition, ensuring timely payments to farmers.
- iii. Enhance access to credit services: Cooperatives should provide better access to credit services and extension programs tailored to the specific needs of their members.
- iv. Promote membership in cooperatives: Strengthening the role of cooperatives in providing financial services can enhance credit market participation, especially for women.
- v. Timely payments: Cooperatives must ensure that farmers receive payments promptly to discourage side selling and enhance retention within the cooperative system.
- vi. Targeted support for Homa Bay farmers: Cooperatives should develop targeted outreach programs to farmers in Homa Bay, addressing specific logistical challenges they face.
- vii. Support for income diversification: Cooperatives should provide training and resources that encourage farmers to explore off-farm income opportunities.
- viii. Promote the economic benefits of membership: Cooperatives should actively promote the financial advantages of membership, highlighting increased income from collective marketing and shared resources.

5.4. Areas for further research

Further research is needed to explore farmers' preferences for services such as input provision and training sessions offered by cooperative societies. These services are designed to incentivize participation, but an empirical evaluation would provide valuable insights into whether they meet the expectations and needs of the farmers. Such an assessment could help determine the effectiveness and satisfaction levels associated with the services, ultimately guiding improvements in cooperative offerings to enhance farmer engagement.

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APPENDICES

Appendix A: Questionnaire

The purpose of this study is to determine the effects of the choice of fresh milk marketing outlets on smallholder dairy farmers credit market participation and income. As a member of a dairy cooperative, you have been selected to participate in this voluntary interview. Your participation is highly valued and will contribute to the success of this research. The information you provide will be used strictly for research purposes and will be treated with the utmost confidentiality. This interview will take approximately one hour, and your responses will offer valuable insights that could help the cooperative's management ensure the sustainability of the business. Additionally, the findings from this research may inform policies aimed at supporting smallholder dairy farmers like yourself. Your cooperation and candid responses are greatly appreciated. Thank you for your time and participation.

SECTION A: HOUSEHOLD IDENTIFICATION AND CHARACTERISTICS

1. Fill in the table below

A1. Household ID: (Barcode scanning) (Type the Barcode number, irrespective of the above)	
A2. Date of Survey (DD/MM/YYYY) :	/ /
A3. Enumerator Name :	
A4. Head of Household Name :	
A5. Head of household gender:	Male / Female
A6. Mobile number:	
A7. National ID for household head:*	
A8. Did the household consent to the interview? (1=YES 2= No)	
A9. If no, why? (code a)	
If no, request replacement household (GPS coordinate) from survey coordinator and finish the survey here.	
A10. County Name:	
A11. Ward Name:	
A12. Name of survey Respondent :	
A13. Respondent gender:	Male / Female

0= grazing only

2= mainly stall feeding with some grazing

3= stall feeding only

4= mainly grazing with some stall feeding

2. Do you USUALLY use AI, when your cow is on heat? 0=NO 1=YES

3. **Cattle owned:** Please enter details for all cattle owned by the household – enter details for each cattle separately

Cattle type (codes)	Breed (0 = local; 1 = exotic/cross)	Number owned by male	Number owned by female	Number owned jointly	Total number owned by household	Number kept in the HH but not owned
Cattle type code						
1. Bulls (> 3 years)		4. Cows (calved at least once)		7. Male calves (between 8 weeks & <1yr)		10.
2. Castrated adult males (oxen> 3 years)		5. Heifers(female ≥1yr,have not calved)		8. Pre weaning males (<8 weeks)		
3. Immature males (<3 years)		6. Female calves (between 8 weeks & <1yr)		9. Pre weaning females (<8 weeks)		

3. What do you feed your livestock on?

1= Napier grass 2= commercial feeds 3= Improved grass 4. Natural grass

4. How much do you spend on the following production activities?

Farm expenditure	No of units	Unit cost	Total in Ksh
Fodder purchase			
Own fodder growth			
Commercial feeds			
Labour (daily wages)			
Family labour			
Water			

Artificial insemination			
Vaccinations			
Transport			
Tick control			
Total			

SECTION C: INSTITUTIONAL FACTORS

1. Do you belong to any producer organization?

1= yes and 0=no

2. Which type of group do you belong to?

1= Dairy farming Self-help 2= cooperative 3= farmer group

4= other (specify).....

3. Over the last one, have you received extension service? 1= yes 0 = no. if yes please fill the below

Agent/ source	Access (1= yes 0= no)	Frequency of access 1= monthly 2= twice a year 3= thrice a year	Was the information useful? (1= yes 0= no)
Government extension worker			
NGO extension			

Farmer to farmer			
Processor extension officers			
Cooperatives			
Others (specify)			

4. Have you borrowed from the groups over the last 3 years? 1= yes 0 = no

5. If yes, what was the purpose of the loan resto milk production?

1= To purchase a cow 2 = To purchase feeds 3 = To buy farm equipment

4= artificial insemination 5= veterinary services 6= other (specify)

.....

6. What was the main source of the loan?

1=Affiliated SACCOs 2= self-help group 3= Bank/microfinance 4= processor

5= other

(Specify).....

7. Have you received any form of financial training over the past one year? (1= yes 0= no)

If yes, who facilitated the training?

1= cooperatives 2= county government 3= NGOs 4= banks 5= other.....

8. Did the training influence your credit repayment?

1= Yes 0= no

If yes, how did it influence loan repayment?

.....

SECTION D: MARKET CHARACTERISTICS

Number of lactating cows: _____

1. Have you been milking any cows in the last one year (October 2020-September 2021)
 1=yes 0=no
2. The number of lactating cows in the last 1 year (October 2020-September 2021)

3. Milk production per cow

Measurement (morning and evening)	Total volume
Milk production per day at calving	
Milk production yesterday	
Milk produced during late lactation	
Average milk produced	

4. Do you sell milk to individual buyers?
5. Do you sell milk to private milk traders?
6. Do you sell dairy cooperative societies?
7. Quantity sold to individual buyers (liters).....
8. Quantity sold to private milk traders (liters).....
9. Quantity sold to dairy cooperatives (liters).....
10. Price received (kshs/liter) from individual buyers.....
11. Price received (kshs/liter) from private milk traders.....
12. Price received (kshs/liter) from cooperatives.....

13. What is the milk payment method used by buyers

- 1=cash, no delay in payment 2= at end of month, no delay 3= cash, no delay in payment
- 4=cash, no delay in payment 5= cash, no delay in payment 6= cash, no delay in payment

14. What the total Distance to buying point (distance to nearest market centre) (Kilometers)

.....

15. Who transports the milk to the buyer point?

- 1= farmer 2= individual buyer usually come for milk 3= cooperative vehicles

SECTION E: LOAN REPAYMENT

1. How much was the loan given in Ksh?

2. What was the repayment period?

3. How much of the loan has been repaid? Ksh.....

4. How much has not been repaid and is overdue?
.....
.....

5. How long has the loan been overdue?
.....

6. Have you been denied a loan in the previous year? (1=yes 0= no)

7. If yes, which of the reasons in the table below resulted into loan denial?

- 1= lack of collateral 2. Failure to repay previous loan 3= low milk production
- 4= low savings 5= other (specify).....

1. Did the choice of marketing outlet influence your loan repayment? (1= yes 0= No)

9. if yes, how
.....
.....

SECTION E: HOUSEHOLD INCOME

1. Did you receive income from the following sources during the past year?

Source of cash	Did you receive any cash income from these sources in the last one year? <i>1=Yes, 0=No</i>	If Yes, how frequently did you receive cash income from these sources? <i>(code)</i>	On average how much did you receive each time from the indicated source	Who in the household received the income and decided on how it was used? (code)
Innovation funds (CBO/Loan from groups)				
Farm labor				
Business (other than farm products)				
Employment or other payment from projects/ government including benefits in kind (e.g. Salary, pensions, aid, subsidies, etc.) Other paid employment				
Renting out your own land				
Loan/credit from a bank or other formal institution (microfinance, projects/programs, registered group)				
Remittance from relatives				
Other source (specify)				
Crops and Livestock sale (excluding Milk)			Total received in 12 months (approximate)	
Sale of Livestock (e.g. shoats, cattle, poultry, etc)				

Sale of Crops (e.g. beans, maize, kales, etc)				
Others (e.g. eggs, honey)				
Frequency of receiving cash 1=Weekly 2=Monthly 3=Annually 4 _____ times		Who decides on how cash is used 1=HHhead (male); 2=HHhead (female); 3=HHhead spouse (female); 4=Other HH male; 5=Other HH female 6=Household joint		

SECTION F: LOAN REPAYMENT

1. How much was the loan given in Ksh?
2. What was the repayment period?
3. How much of the loan has been repaid? Ksh.....
4. How much has not been repaid and is overdue?

.....
.....

5. How long has the loan been overdue?
-

6. Have you been denied a loan in the previous year? (1=yes 0= no)

7. If yes, which of the reasons in the table below resulted in loan denial?

- 1= lack of collateral 2. Failure to repay the previous loan 3= low milk production
4= low savings 5= other (specify).....

2. Did the choice of marketing outlet influence your loan repayment? (1= yes 0= No)

9. if yes, how
-
.....

Thank you.

Appendix B: Key Data analysis for objective one

Multivariate Probit Model results

```
. movestay logexpIncome age2 hhhgender Leveleduc2 off_farmincome Experience2 Hhsize CredAcc AccExtension hrd_size c5a_breed_typ_ai pric
> e_litr location_Homabay , select( Cooperative = Distance_market milk_payment )
```

Fitting initial values

```
Iteration 0: log likelihood = -381.0894
Iteration 1: log likelihood = -379.05399
Iteration 2: log likelihood = -378.99263
Iteration 3: log likelihood = -378.99257
Iteration 4: log likelihood = -378.99257
```

```
Endogenous switching regression model      Number of obs =      277
                                           Wald chi2(12) =     174.98
Log likelihood = -378.99257                Prob > chi2       =      0.0000
```

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
logexpIncome_1						
age2	.0000446	.0000426	1.05	0.296	-.000039	.0001281
hhhgender	-.1594444	.1524322	-1.05	0.296	-.4582061	.1393173
Leveleduc2	.0037342	.0008829	4.23	0.000	.0020038	.0054646
off_farmincome	.9489285	.1448632	6.55	0.000	.6650019	1.232855
Experience2	.0000946	.0001088	0.87	0.385	-.0001187	.0003078
Hhsize	-.002102	.0344528	-0.06	0.951	-.0696283	.0654243
CredAcc	-.0811978	.1394987	-0.58	0.561	-.3546103	.1922147
AccExtension	.1879463	.1495709	1.26	0.209	-.1052072	.4810999
hrd_size	.0312933	.0221652	1.41	0.158	-.0121498	.0747363
c5a_breed_typ_ai	-.0179471	.1502246	-0.12	0.905	-.3123819	.2764877
price_litr	.0274864	.0143993	1.91	0.056	-.0007358	.0557085
location_Homabay	.5129072	.4553501	1.13	0.260	-.3795626	1.405377
_cons	10.34491	.5059923	20.44	0.000	9.353183	11.33664
logexpIncome_0						
age2	.0000349	.0000489	0.71	0.475	-.0000609	.0001306
hhhgender	-.0645432	.1865048	-0.35	0.729	-.4300859	.3009996
Leveleduc2	.0026085	.0009447	2.76	0.006	.0007569	.0044602
off_farmincome	.7912415	.1658262	4.77	0.000	.4662281	1.116255
Experience2	-.0001262	.0001452	-0.87	0.384	-.0004107	.0001583
Hhsize	-.0017539	.0347872	-0.05	0.960	-.0699355	.0664278
CredAcc	.0224513	.1539911	0.15	0.884	-.2793657	.3242683
AccExtension	-.0024309	.1537636	-0.02	0.987	-.3038021	.2989403
hrd_size	-.0582094	.0270246	-2.15	0.031	-.1111765	-.0052422
c5a_breed_typ_ai	.1179579	.1958086	0.60	0.547	-.2658198	.5017356
price_litr	.0423987	.0121954	3.48	0.001	.0184963	.0663012
location_Homabay	-.0848348	.2258187	-0.38	0.707	-.5274314	.3577618
_cons	9.602557	.5607327	17.13	0.000	8.503541	10.70157
Cooperative						
age2	-.0000212	.0000818	-0.26	0.796	-.0001815	.0001391
hhhgender	-.1553415	.3402309	-0.46	0.648	-.8221817	.5114987
Leveleduc2	.0027662	.0017355	1.59	0.111	-.0006353	.0061676
Experience2	.0002887	.0002442	1.18	0.237	-.0001901	.0007674
CredAcc	.3455629	.3029717	1.14	0.254	-.2482506	.9393764
AccExtension	-.0124012	.3114131	-0.04	0.968	-.6227598	.5979573
hrd_size	.1214011	.0493094	2.46	0.014	.0247564	.2180458
c5a_breed_typ_ai	.2981589	.2981871	1.00	0.317	-.286277	.8825948
price_litr	-.04423	.0238547	-1.85	0.064	-.0909844	.0025243
off_farmincome	-.2088585	.3021494	-0.69	0.489	-.8010605	.3833436
Hhsize	.0145667	.0732986	0.20	0.842	-.1290959	.1582293
location_Homabay	-2.349174	.4539477	-5.17	0.000	-3.238896	-1.459453
Distance_market	.1860912	.0850878	2.19	0.029	.0193222	.3528603
milk_payment	-1.9795	.3004014	-6.59	0.000	-2.568276	-1.390724
_cons	1.584095	.9142912	1.73	0.083	-.2078832	3.376072
LR test of indep. eqns. :						
/lns1	-.4185928	.0768492	-5.45	0.000	-.5692145	-.2679712
/lns2	-.0669645	.0572923	-1.17	0.242	-.1792552	.0453263
/r1	-.7028484	.4028359	-1.74	0.081	-1.492392	.0866956
/r2	-.7070961	.2460131	-2.87	0.004	-1.189273	-.2249194
sigma						
sigma_1	.657972	.0505646			.5659699	.7649298
sigma_2	.9352284	.0535814			.8358925	1.046369
rho_1	-.6061726	.2548158			-.903764	.086479
rho_2	-.6088526	.1548156			-.8303532	-.2212018
LR test of indep. eqns. : chi2(1) = 12.35 Prob > chi2 = 0.0004						

Appendix C: Key Data analysis for objective two

```
. logit avii_crdt_mrkt Age_youth hrdsz i.hhhgender AccExtension assoctn_Mmbrshp Cooperative land off_farmincome formal_education fdng_sytm
```

```
Iteration 0: log likelihood = -182.80014
Iteration 1: log likelihood = -168.42694
Iteration 2: log likelihood = -168.27823
Iteration 3: log likelihood = -168.2782
Iteration 4: log likelihood = -168.2782
```

```
Logistic regression                Number of obs   =       277
                                LR chi2(10)      =       29.04
                                Prob > chi2        =       0.0012
Log likelihood = -168.2782        Pseudo R2       =       0.0794
```

avii_crdt_mrkt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Age_youth	-.7929219	1.284985	-0.62	0.537	-3.311447	1.725603
hrdsz	-.1133911	.3066396	-0.37	0.712	-.7143937	.4876115
hhhgender						
male	.9421354	.34657	2.72	0.007	.2628707	1.6214
AccExtension	.5229104	.2915222	1.79	0.073	-.0484626	1.094283
assoctn_Mmbrshp	.7478991	.2737383	2.73	0.006	.2113819	1.284416
Cooperative	-.176254	.2860594	-0.62	0.538	-.7369201	.3844121
land	1.031551	.3560886	2.90	0.004	.3336302	1.729472
off_farmincome	.1136517	.2844004	0.40	0.689	-.4437627	.6710662
formal_education	-.2775956	.3146553	-0.88	0.378	-.8943087	.3391175
fdng_sytm	-.476236	.3081673	-1.55	0.122	-1.080233	.1277608
_cons	-1.715169	.5096268	-3.37	0.001	-2.714019	-.7163189

```
Expression : Pr(avii_crdt_mrkt), predict()
```

```
dy/dx w.r.t. : Age_youth hrdsz 1.hhhgender AccExtension assoctn_Mmbrshp Cooperative land off_farmincome formal_education fdng_sytm
```

```
at : Age_youth = .0108303 (mean)
    hrdsz = .7292419 (mean)
    0.hhhgender = .2418773 (mean)
    1.hhhgender = .7581227 (mean)
    AccExtension = .5776173 (mean)
    assoctn_Mmbrshp = .4584838 (mean)
    Cooperative = .4187726 (mean)
    land = .1768953 (mean)
    off_farmincome = .6425993 (mean)
    formal_education = .6714801 (mean)
    fdng_sytm = .2851986 (mean)
```

	Delta-method					
	dy/dx	Std. Err.	z	P> z	[95% Conf. Interval]	
Age_youth	-.1820491	.2949945	-0.62	0.537	-.7602278	.3961296
hrdsz	-.0260338	.0703982	-0.37	0.712	-.1640117	.1119442
hhhgender						
male	.1971617	.0639065	3.09	0.002	.0719073	.322416
AccExtension	.1200564	.0668004	1.80	0.072	-.01087	.2509828
assoctn_Mmbrshp	.1717122	.0625875	2.74	0.006	.0490429	.2943815
Cooperative	-.0404666	.0656502	-0.62	0.538	-.1691387	.0882055
land	.2368366	.0816661	2.90	0.004	.076774	.3968992
off_farmincome	.0260936	.0652802	0.40	0.689	-.1018531	.1540404
formal_education	-.0637339	.0722404	-0.88	0.378	-.2053225	.0778546
fdng_sytm	-.1093403	.0706294	-1.55	0.122	-.2477714	.0290907

Appendix D: Key Data analysis for objective three

```
. movestay logexpIncome age hhhgender Leveleduc off_farmincome Experience Hhsize CredAcc AccExtension hrd_size c5a_breed_typ_ai price_l
> itr location_Homabay , select( Cooperative = Distance_market milk_payment )
```

Fitting initial values

```
Iteration 0: log likelihood = -380.48159
Iteration 1: log likelihood = -378.53729
Iteration 2: log likelihood = -378.4764
Iteration 3: log likelihood = -378.47633
Iteration 4: log likelihood = -378.47633
```

```
Endogenous switching regression model      Number of obs   =      277
                                           Wald chi2(12)   =     173.45
Log likelihood = -378.47633                Prob > chi2     =     0.0000
```

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
logexpIncome_1						
age	.00461	.0051768	0.89	0.373	-.0055363	.0147562
hhhgender	-.158424	.1522413	-1.04	0.298	-.4568116	.1399635
Leveleduc2	.0037096	.0008814	4.21	0.000	.001982	.0054371
off_farmincome	.945969	.1446422	6.54	0.000	.6624755	1.229463
Experience	.0047884	.0057066	0.84	0.401	-.0063963	.0159732
Hhsize	-.0028954	.0344415	-0.08	0.933	-.0703994	.0646087
CredAcc	-.0798636	.1397488	-0.57	0.568	-.3537662	.1940391
AccExtension	.1878965	.1499436	1.25	0.210	-.1059876	.4817806
hrd_size	.031339	.0221985	1.41	0.158	-.0121692	.0748473
c5a_breed_typ_ai	-.0230332	.1511233	-0.15	0.879	-.3192295	.273163
price_litr	.0275058	.014416	1.91	0.056	-.0007491	.0557607
location_Homabay	.4825545	.4541827	1.06	0.288	-.4076271	1.372736
_cons	10.20416	.5548275	18.39	0.000	9.116722	11.29161
logexpIncome_0						
age	.0056887	.0058677	0.97	0.332	-.0058118	.0171891
hhhgender	-.0596199	.1878526	-0.32	0.751	-.4278043	.3085645
Leveleduc2	.0026582	.0009422	2.82	0.005	.0008115	.0045049
off_farmincome	.7911317	.1654774	4.78	0.000	.4668021	1.115461
Experience	-.0056287	.0073435	-0.77	0.443	-.0200216	.0087643
Hhsize	-.0001144	.034705	-0.00	0.997	-.0681351	.0679062
CredAcc	.028029	.1537863	0.18	0.855	-.2733866	.3294446
AccExtension	-.0061161	.1537447	-0.04	0.968	-.3074501	.2952179
hrd_size	-.0581606	.0269986	-2.15	0.031	-.1110769	-.0052442
c5a_breed_typ_ai	.1242909	.195614	0.64	0.525	-.2591055	.5076873
price_litr	.0421616	.0122041	3.45	0.001	.0182421	.0660812
location_Homabay	-.0906674	.2263167	-0.40	0.689	-.5342399	.3529051
_cons	9.434303	.6245369	15.11	0.000	8.210233	10.65837
Cooperative						
hhhgender	-.1646055	.3460567	-0.48	0.634	-.8428642	.5136531
Leveleduc2	.0028146	.0017278	1.63	0.103	-.0005719	.0062011
off_farmincome	-.2067014	.30062	-0.69	0.492	-.7959058	.3825029
Experience	.0191323	.0124047	1.54	0.123	-.0051804	.0434451
CredAcc	.3508571	.3055536	1.15	0.251	-.248017	.9497312
AccExtension	-.0303694	.3150107	-0.10	0.923	-.6477791	.5870403
hrd_size	.1201777	.0496246	2.42	0.015	.0229154	.2174401
c5a_breed_typ_ai	.2957883	.3001945	0.99	0.324	-.2925822	.8841588
price_litr	-.0450195	.0239737	-1.88	0.060	-.0920072	.0019681
location_Homabay	-2.352351	.4592069	-5.12	0.000	-3.25238	-1.452322
age	-.00433	.0103064	-0.42	0.674	-.0245302	.0158702
Hhsize	.0122056	.0740329	0.16	0.869	-.1328961	.1573074
Distance_market	.1854128	.0857267	2.16	0.031	.0173917	.353434
milk_payment	-2.01651	.3036968	-6.64	0.000	-2.611744	-1.421275
_cons	1.629973	1.036463	1.57	0.116	-.401457	3.661404
LR test of indep. eqns. :						
/lns1	-.4181082	.0766178	-5.46	0.000	-.5682764	-.26794
/lns2	-.0691356	.0571227	-1.21	0.226	-.1810941	.0428229
/r1	-.693526	.3977883	-1.74	0.081	-1.473177	.0861247
/r2	-.6853529	.2472357	-2.77	0.006	-1.169926	-.2007799
sigma						
sigma_1	.658291	.0504368			.566501	.7649537
sigma_2	.9332001	.0533069			.8343568	1.043753
rho_1	-.6002424	.2544688			-.9001817	.0859124
rho_2	-.5949883	.1597115			-.8242484	-.1981247

```
LR test of indep. eqns. :      chi2(1) =    11.84   Prob > chi2 = 0.0006
```

```

. mspredict xx, yc1_1
.
. mspredict xy, yc1_2
. mspredict yy, yc2_2
. mspredict yx, yc2_1
. sum xx xy yy yx

```

Variable	Obs	Mean	Std. Dev.	Min	Max
xx	116	12.69684	.7882359	10.71791	14.68107
xy	161	13.16401	.6683428	11.22106	14.94274
yy	161	11.93025	.6228815	10.67075	13.49117
yx	116	11.66135	.6609756	10.20814	12.7633

```
. ttest xx== yx
```

Paired t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
xx	116	12.69684	.0731859	.7882359	12.55187	12.84181
yx	116	11.66135	.06137	.6609756	11.53979	11.78291
diff	116	1.035488	.0376905	.4059386	.9608303	1.110145

```

mean(diff) = mean(xx - yx)          t = 27.4735
Ho: mean(diff) = 0                  degrees of freedom = 115

Ha: mean(diff) < 0                  Ha: mean(diff) != 0          Ha: mean(diff) > 0
Pr(T < t) = 1.0000                  Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

```

```
. ttest xy==yy
```

Paired t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
xy	161	13.16401	.0526728	.6683428	13.05999	13.26803
yy	161	11.93025	.0490899	.6228815	11.8333	12.0272
diff	161	1.23376	.0369241	.468514	1.160839	1.306682

```

mean(diff) = mean(xy - yy)          t = 33.4134
Ho: mean(diff) = 0                  degrees of freedom = 160

Ha: mean(diff) < 0                  Ha: mean(diff) != 0          Ha: mean(diff) > 0
Pr(T < t) = 1.0000                  Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

```

```

. teffects ipwra ( logExpIncome age milk_payment hhhgender Leveleduc off_farmincome Experience Hhsize CredAcc AccExtension hrd_size Dista
> nce_market c5a_breed_typ_ai price_litr)(Cooperative age milk_payment hhhgender Leveleduc off_farmincome Experience Hhsize CredAcc AccE
> xtension hrd_size Distance_market c5a_breed_typ_ai price_litr), aequations

```

```

Iteration 0: EE criterion = 2.211e-26
Iteration 1: EE criterion = 3.935e-31

```

```

Treatment-effects estimation          Number of obs   =      277
Estimator      : IPW regression adjustment
Outcome model  : linear
Treatment model: logit

```

	logExpIncome	Robust		z	P> z	[95% Conf. Interval]	
		Coef.	Std. Err.				
ATE							
	Cooperative (yes vs no)	.4770216	.2738846	1.74	0.082	-.0597822	1.013826
POMean							
	Cooperative no	10.35335	.1798504	57.57	0.000	10.00085	10.70585

Appendix E: Research Permit

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Appendix F: Publication

Onyango et al., *Cogent Food & Agriculture* (2023), 9: 2291225
<https://doi.org/10.1080/23311932.2023.2291225>



FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Impact of cooperatives on smallholder dairy farmers' income in Kenya

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Received: 21 March 2023
Accepted: 30 November 2023

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Reviewing editor:
Pedro González-Redondo, University of Seville, Spain

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Abstract: Apart from generating Gross Domestic Product (GDP), the dairy industry in Kenya contributes to the employment of over a million people along the milk value chain. The sub-sector, however, still experiences low productivity and extensive informal marketing. Farmers have, therefore, formed cooperative societies that have received support in cooling plants and access to dairy services, animal health and artificial insemination. However, participation by members of these cooperative societies is still low, and participation's impact on income has not been determined. This study sought to assess the impact of the choice of cooperatives on smallholder dairy farmers' incomes. Data was collected using a semi-structured questionnaire from a sample of 277 Nyamira and Homa Bay Counties farmers. An endogenous switching regression model was used to analyze data. The results indicated that cooperative market participation increased farmers' incomes by about 10%. The results also revealed that distance to market, milk payment period, number of lactating cows, farm size, and farmer location influenced farmers' decision to participate in the cooperatives. Furthermore, the level of education, number of lactating cows, farm size, access to off-farm income and access to extension services were significant in determining farmers' income. This paper suggests policies that increase cooperative market participation for smallholder dairy farmers in Kenya.