PARTICIPATION IN MILK PROCESSING AND ITS EFFECT ON PROFITABILITY OF THE DAIRY ENTERPRISE AMONG SMALLHOLDER FARMERS: THE CASE OF KIKIMA DAIRY COOPERATIVE SOCIETY IN MAKUENI COUNTY, KENYA

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This thesis is my original work and has not been presented for examination in any university.

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This thesis is dedicated to my parents and siblings.

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ABBREVIATIONS AND ACRONYMS

AI	Artificial Insemination
ATT	Average Treatment of the Treated
ATU	Average Treatment Effect on the Untreated
CIMP	County Integrated Development Plan
Coef	Coefficient
ESR	Endogenous Switching Regression
FAO	Food and Agricultural Organization of the United Nations
FIML	Full Information Maximum Likelihood
GDP	Gross Domestic Product
GOK	Government of Kenya
Ha	Hectares
HE	Heterogeneity Effect
IFAD	International Fund for Agricultural Development
IMR	Inverse Mills Ratio
IV	Instrumental Variable Method
Km	Kilometers
KNBS	Kenya National Bureau of Statistics
Kshs	Kenya shillings
L	Litres
Max	Maximum
Min	Minimum
Mm	Millimeter

MoALF	Ministry of Agriculture Livestock and Fisheries
MP	Milk Processing
N	Sample size
MP	Milk processing participation
NMP	Non participation in milk processing
ODK	Open Data Kit
PSM	Propensity Score Matching Method
SD	Standard Deviation
SDG	Sustainable Development Goals
SDP	Smallholder Dairy Project
Std. Err.	Standard Error
UN	United Nations
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
VIF	Variance Inflation Factor

ABSTRACT

The role of the dairy sector in Kenya with respect to the creation of employment, food & nutrition security cannot be overlooked. Smallholder farmers rely on it as their source of livelihood. The sector is however faced with a number of challenges. For instance, low milk processing capacity which can potentially increase the shelf life and retail price of milk, thus having a significant effect on the milk income realized by smallholder farmers. It is based on this scenario that providing a reliable ready market for dairy farmers in Makueni County was deemed important, thus necessitating the establishment of the Kikima dairy plant in the year 1971. The dairy plant has been operational for the last 51 years. However, its effect on the profitability of the dairy enterprise of the target population is not well known. This study, therefore, assessed the effect of participation in milk processing on milk income realized by smallholder farmers. The study utilized cross-section data obtained from a sample of 200 smallholder dairy farmers from Makueni County. Both descriptive and empirical analyses were utilized. Gross margin analysis, probit model, and endogenous switching regression models were applied. Descriptive statistics showed existence of significant differences in individual socio-economic characteristics between milk processing participants and non-participants. Factors identified to significantly influence participation in milk processing include; age, experience, sex, education and farming as the primary occupation. The effect estimates showed a negative and significant effect of participating in milk processing on milk income. Based on the low profitability of the dairy enterprise among the participants despite having higher milk productivity per cow as compared to non-participants, this study recommends that the plant management should consider offering a quality-based payment to the project participants in order to boost their income levels and attract participation by other farmers.

Additionally, the study recommends the introduction of a structured trading system in order to influence participation into the project.

Keywords: Endogenous Switching Regression Model, effect, milk processing, participation, smallholder farmer.

CHAPTER ONE: INTRODUCTION

1.1 Background information

The growing consumer demand for livestock products due to population growth is changing livestock systems globally (Willer et al., 2013). According to UN Report (2016), the African population is projected to increase to about 4.4 billion by the year 2100. Consequently, this will lead to an increase in the demand for milk (Holechek et al., 2017) and the per capita consumption of fresh dairy products by an average of 1.9 percent per annum (FAO, 2019).

In Kenya, the per capita consumption of milk is estimated to be 110 litres (SDP, 2004). The dairy industry in Kenya contributes to about 17 percent and 4.5 percent of the agricultural GDP and the Kenyan GDP respectively (MoLD, 2006). The dairy sector generates an estimated 1 million, 0.5 million, and 0.5 million jobs at the farm level, direct wage employment, and in support services respectively. Hence the dairy sector is important in poverty eradication (USAID, 2015). Kenya exports substantial milk products which include milk powder, long-life milk, and ghee estimated at 10.9 million kilograms per annum (KDB, 2019).

There are more than 1.8 million smallholder milk-producing households that own one to three cows in the country (IFAD & UNEP, 2013). The dairy cattle population in Kenya is estimated at 4.3 million, of whom eighty percent is owned by smallholder farmers (Peeler et al., 2000). The country produces on average 5.1 billion litres of milk per annum against a milk demand of 5.2 billion litres. This leaves the country with a deficit of 100 million litres of milk every year. This

high demand is attributable to a rising middle class, increasing urbanization, and export opportunities within East Africa (KDB, 2019).

The milk processing capacity in the country still remains low at 648 million litres annually (KDB, 2019). However, processors still do not operate optimally due to competition from the informal sector and seasonality of the produce (FAO, 2017). The milk production levels still remain low due to the challenge of climate change which negatively affects fodder production, because the majority of farmers rely on rain for fodder production (KDB, 2019).

The dairy farmers in Makueni County continue to adopt exotic dairy cattle breeds hence cows of the local breed are steadily decreasing (Kavoi et al., 2013). The County's dairy cow population is estimated at 22,353 with estimated total milk production of approximately 26 million litres against a demand of 340 million litres and a processing capacity of 0.47 million litres per annum. The sector has been found to employ about 21-40 percent of the entire population in the county with production being dominated by smallholder farmers who account for 80 percent of the total milk produced (MoALF, 2019). On average each dairy farmer owns between one to four animals (MoALF, 2019).

The revitalization of the Makueni County dairy sector started with the artificial insemination program funded by the county government in the year 2014. The objective was to produce breeds that are adaptable to the local climatic conditions and genetically high-yielding. The second

initiative entailed rolling out a project characterized by massive fodder farming promotion. All these initiatives, strategically geared toward expanding milk productivity in the county of Makueni, were complemented by enhancing the operational capacity of the Kikima milk processing plant which entailed increasing its processing capacity to provide a ready market to the smallholder farmers (Makueni County CIMP, 2013 - 2017).

The Kikima milk processing plant is located in Makueni County, within Mbooni sub-county. The dairy plant was established by the members of Kikima Dairy Cooperative Society in the year 1971 targeting smallholder dairy farmers within Makueni County and has been operational for the last 51 years. The milk processing plant later received support in form of a grant to acquire additional equipment to increase its processing capacity from the area county government in the year 2014. The dairy plant is owned by 951 members of Kikima Dairy Cooperative Society. The processing capacity of the plant is estimated at 300 litres per hour and 6,600 litres of milk per day (Kikima Dairy Plant Annual Review Report, 2020).

The plant so far has acquired an additional storage tank, pasteurizer machine, and packaging equipment which have improved its value addition capability. The plant produces three products; mala milk, fresh milk, and pasteurized branded milk dubbed ‘Makueni Fresh’. So far, the plant has secured a ready market for its products with nearby supermarkets and schools (Kikima Dairy Plant Annual Review Report, 2020). However, milk production in Makueni County faces the challenge of seasonal fluctuation of production and poor infrastructure whereby the milk-producing areas tend to have poor road networks as well as competition with informal milk trade (MoALF, 2019).

1.2 Statement of the research problem

The role of the dairy sector in Makueni county with respect to employment creation and food and nutrition security cannot be overlooked, as the few conventional cash crops are affected by the low reliability of rainfall, which in turn leads to drought and crop failure (Njarui et al., 2011). Despite its importance, the dairy sector is constrained by inadequate processing capacity (Muriuki, 2003). One way of dealing with this challenge is through the formation of agricultural cooperatives (Green & Knechtges, 2015) as seen in the case in Makueni County with the establishment of the Kikima Dairy Cooperative Society milk processing.

Since its inception in 1971, Kikima milk processing plant has had remarkable progress. For example, setting up a cold room, acquiring additional standard cooling equipment, procuring an additional pasteurizer machine, and packaging equipment. Hence it has improved value addition capacity (Kikima Dairy Plant Annual Review Report, 2020). However, its contribution to the welfare in terms of effect on the profitability of the dairy enterprise is not well known. There is lack of empirical studies that have evaluated the effect of Kikima milk processing plant on the dairy enterprise profitability. Thus, it is not clear whether the milk processing plant has made any noticeable welfare and livelihood changes in terms of farm income generated from the dairy enterprise and contribution to the economic empowerment of the dairy farmers.

There has been extensive research on the effect of developmental projects on farmers' welfare in Kenya and other parts of the world. For instance; Mwambi *et al.,* (2016), Lizarralde (2008), Mmbando (2014), Manda *et al.,* (2021), Cai *et al.,* (2008), Feng *et al.,* (2020), Tuan (2012).

However, there is scanty knowledge regarding the effect of agro-processing developmental projects initiated by the devolved system of governments in Kenya. Therefore, the current study fills this gap in knowledge by studying the case of Kikima Dairy Cooperative Society milk processing plant in Makueni County.

1.3 Research objectives

The general objective of this study was to evaluate participation in milk processing and its effect on profitability of the dairy enterprise among smallholder farmers in Makueni County, taking the case of Kikima Dairy Cooperative Society milk processing plant.

The specific objectives of this study were;

i. To describe the socio-economic, farm, and institutional characteristics of participants and non-participants of milk processing.
ii. To assess the profitability of milk production among participants and non-participants in milk processing.
iii. To assess determinants of participation in milk processing among smallholder dairy farmers.
iv. To evaluate the effect of participation in milk processing on milk income among smallholder dairy farmers.

1.4 Hypotheses

i. There is no significant difference in the individual socio-economic, farm, and institutional characteristics among the smallholder farmers who participate in milk processing and those who do not.

ii. There is no significant difference in the profit realized by smallholder farmers who participate in milk processing and those who do not.

iii. Individual socio-economic, farm and institutional factors do not influence smallholder farmers' participation in milk processing.

iv. Participation in milk processing has no effect on milk income among smallholder dairy farmers.

1.5 Justification

About 60 percent of individuals in marginal areas like Makueni County are employed in the agriculture sector (KIPPRA, 2020). Makueni County has a low household income with 30.7 percent of its residents living below the poverty line (KNBS, 2010). Moreover, food security in this county is negatively affected by the fact that the few established cash crops are affected by low rainfall reliability which results in drought and crop failure and this worsens the situation (Mbithi & Van Huylenbroeck, 2000). Thus, the dairy sector's significance in Makueni County cannot be overlooked.

The results of this research study will provide empirical evidence on the contribution of the dairy plant to farmers' income with regard to the laid objectives, as well as aid the plant management in

identifying approaches for scaling up the plant activities. The results of this study will help the county government of Makueni to understand its contribution towards the realization of Sustainable Development Goal (SDG) 8.2 focusing on achieving high levels of economic productivity through technological upgrading and focusing on high value-added sectors. This study is also in line with the Makueni county government's goal of poverty eradication by increasing smallholder income through supporting farmer organizations (Makueni county CIMP 2013 – 2017).

This study conforms to Sustainable Development Goal (SDG) 17.6.2 focusing on encouraging and promoting effective public-private and civil society partnerships. Understanding the effect of the Kikima dairy plant is of importance in generating information for policy makers and the project funders (Makueni county government and Kikima Cooperative Society members) on the progress of the plant as well provide information on possible areas for further partnership and improvement.

1.6 Organization of the thesis

This thesis is structured into five chapters. The first chapter provides the introduction, statement of the research problem, objectives, hypotheses of the study, and justification. The second chapter comprises a detailed literature review and theoretical framework. Chapter three provides the research methodology, consisting of empirical models used in the analysis, data types, data collection methods, analysis software used, sample size determination, sampling procedure, description of the study area, and model diagnostic tests conducted. The study results are presented

and discussed in Chapter four. Finally, a summary of the findings, conclusions, policy recommendations, and recommendations for further research are presented in Chapter five.

CHAPTER TWO: LITERATURE REVIEW

2.1 Dairy Sector in Kenya

The dairy sub-sector contributes to the livelihoods and nutrition of the rural communities hence has the potential of contributing to the country's goals such as Vision 2030 (Wanjala *et al.,* 2015). The sector contributes about 4.5% of gross domestic product (GDP). There has been an increase in milk production with an average of 5.3% annually and increase in processing capacity at an average of 7% per year, per capita consumption of milk averaging at 5.8% annually (Rademaker *et al*.,2016). Kenya experiences a growing demand for milk and dairy products due to urbanization and a rising middle class.

The sector is mainly dominated by smallholders with approximately 3.8 million dairy cattle, and production is estimated at 5 billion litres of milk annually (Kenya National Bureau of Statistics, 2019). Smallholder dairy farmers contribute more than 70% of gross dairy product marketed. Other players in dairy production are co-operative societies and farmers groups who handle 40% of total milk marketed (Wanjala *et al.,* 2015). Dairy sector has been linked to significant contributions to livelihoods and income generation among smallholder farmers. It is a source of employment and income generation, which includes both self-employment and market agents, hired labour on farm and in the market (Smale *et al*., 2012). Small scale Dairy farming is majorly practiced in the highlands of the Rift Valley and Central regions and the Coastal lowlands. Smallholder dairy farms are highly concentrated in peri-urban area mainly due to the ease of access to channels of marketing milk. Most of the Smallholder dairy farmers keep 2 or 3 dairy cows, on approximately one hectare of land. According to

Staal (2014), large-scale dairy farms are mainly owned by both public institutions, private firms, such as the Agricultural Development Corporation (ADC). Friesian cattle are the dominant breed, but Jersey and Ayrshire breeds are also found with some farms in the dry areas keeping cross breed of Sahiwal with Bos Taurus breeds.

2.2 Milk Production Status and Trends

There are significant and positive changes in the dairy industry which has resulted in a major shift and focus towards market-oriented production among the smallholders. This could be mainly caused by climatic conditions, high and rising urban population, significantly improved fodder technology among dairy cattle population, high incomes and the high consumption of milk and dairy products (Kinambuga, 2010). Kenya is among the leading African milk producing countries, in terms of volume accounting for 48% together while Sudan, Egypt, South Africa and Algeria each producing 52% of the total milk in Africa. Kenya is estimated to produce more than 4 billion litres of milk per year, mainly from central and rift valley regions.

Due to growth in human population, the demand for livestock products has risen and it is estimated that twice as much milk and meat will have to be produced in the next 30-35 years to satisfy this demand (Wamjala *et al.*, 2011). Thus, livestock production will have to be even more intensive. It will also depend heavily on efficient and effective use of inputs, which will require increased knowledge of better farm or enterprise management. In addition, information will be required to support new enterprise development in response to changing farming systems, increased demand for livestock products and opportunities for investment in

livestock as financial incentives increase (Kinambuga, 2010).

2.3 The dairy industry in Makueni County

The dairy cows reared by farmers in Makueni County comprise of both local and exotic breeds. The common exotic breeds found in Makueni County are Friesian, Ayrshire, and Guernsey. On average, milk productivity is six litres per cow per day (MoALF, 2019). The dairy sub-sector in this county is dominated by smallholder dairy farmers who rely on it as a source of livelihood. On average, the farmers in this area own between one and three cows, with the highest productivity being among the male-headed households (KIPPRA, 2020). The main value addition activities in Makueni County are; boiling, fermenting, cooling, making yogurt, and cooling. However, value addition at the farm level remains low since the majority of the smallholder dairy farmers do it when production is high over the rainy season (MoALF, 2019).

2.4 Role of smallholder dairy farming on household welfare

Dairy farming plays an important role in the socioeconomic status of rural households (Bryan *et al*., 2013). Chagunda *et al*., (2016), using examples from Kenya, Malawi, Mozambique, Tanzania, and Zambia, similarly demonstrated that dairy farming is an important agricultural enterprise that supports food and nutrition security as well as household income for poor households. Smallholder dairy enterprises do not only serve individual households but also supply the bulk of the milk in the dairy value chain in developing countries and a considerable contribution to national gross domestic product (Chagunda *et al*., 2016; Odero-Waitituh, 2017).

Bryan *et al*., (2013) reported that there are various benefits that can be derived from dairy production if appropriate and holistic strategies are put in place. For instance, dairy farming has also been linked to increased access to and control of income and women participation in decision-making of household expenditure at household level (FAO, 2011). Dairy production as an enterprise provides a regular source of income, hence enabling households to increase food diversity (FAO, 2011). Kabunga *et al*., (2017) associated less child stunting and improved income with dairy ownership in Uganda while Yasmin and Ikemoto (2015) associated dairy farming with substantial reduction in poverty among women in Bangladesh. Similar contributions from dairy sector are reported in other developing countries (Olwande *et al*., 2015; Chagwiza *et al*., 2016; Kebebe, 2017).

In comparison to crop enterprises, the contribution of dairy farming to household income manifests in various ways. A household can obtain income from milk sales, animal sales, manure sales, and use of manure as fertilizer. Dairy farmers have been found to use the income from milk sales to purchase other food and non-food items, such as paying for hospital bills, school fees, and other services (Kalumikiza, 2012). Chagunda *et al*., (2016) recommended smallholder dairying as a tool to enhance livelihood of rural poor households.

2.5 The concept of effect assessment

Effect evaluations are conducted using quantitative methods before or after an intervention is done (Khandker et al., 2010). There are two types of quantitative effect assessments namely *ex-ante* and *ex-post* evaluations. The *ex-ante* assessments attempt evaluate the effect of forthcoming programs

given the current situation on the target area using available data before the program or policy intervention (Bourguignon et al., 2003). In contrast, *ex-post* assessments measure the real effects amassed by the beneficiaries which can be attributed to certain project(s) or policy intervention(s) (Khandker *et al.*, 2010).

An *ex-post* evaluation, therefore, involves reflexive comparisons between the difference in participants' outcomes before and after the project's or program's implementation or across the participants and non-participants (Aakvik et al., 2005). *Ex-post* evaluations are beneficial in that they reflect reality. However, they are more costly to implement compared to an *ex-ante* evaluation as they require data on real outcomes for the participant and non-participant groups, along with the socio-economic features which might have influenced participation (Gertler et al., 2011).

2.6 Methodological issues in effect assessment

Effect evaluation of projects and programmes such as the adoption of technologies or participation in a project, aim at providing policy makers with information pertaining to the net effect of such interventions on the target group. This, therefore, provides evidence to the decision makers as to whether or not an intervention is producing the intended results (Baker, 2000). Causal inference encompasses the elementary question in measuring the effect of any given intervention with respect to a particular outcome. This makes it possible to find out what effects these interventions have had on the outcome variable. Effect assessment techniques are thus used to exclude any other

factors that may have led to a similar outcome (Baker, 2000). This is done by observing the same individual at different points of the project or intervention but at the same time (Ferraro, 2009).

2.7 Review of methods for effect analysis and previous studies

Several empirical methods have been applied in similar studies at both macro and micro levels. These methods include; cost-benefit analysis, economic surplus approach and econometric estimation techniques. The cost-benefit and economic surplus methods assume either perfectly inelastic or perfectly elastic supply or demand, which is not always the reality in many scenarios and this points to their weakness (Baker, 2000). The economic surplus method is advantageous over the cost-benefit analysis method because it incorporates international price and distribution effects. However, the economic surplus approach suffers from measurement errors and does not take into consideration the general equilibrium effects, transaction costs and externalities (Alston, 2008).

In experimental methods, the selection of treatment and control groups is done randomly within well-defined study subjects. The randomized control design is however limited to experimental studies because they are costly in most cases (J. J. Heckman et al., 1998). Moreover, randomized control design requires close monitoring to ensure effective administration and also encounter ethical challenges due to their denial of participation for other eligible members of the population and therefore not widely used in social-economic studies (Khandker *et al*., 2010).

The quasi-experimental design entails selecting groups upon which a variable is tested without any random pre-selection process. Thus, it resembles quantitative and qualitative experiments but they lack random allocation of groups or proper controls and therefore firm statistical analysis can be very difficult (Khandker *et al*., 2010). After the selection of the groups, the experiment proceeds in a very similar way to any other experiment. The quasi-experimental design is frequently used with distinct case studies where the figures and findings generated are used to support the conclusions in a case study in order to permit some analysis to take place (J. J. Heckman, Lochner, & Taber, 1998).

Non-experimental methods are used in assessments when experimental designs cannot be applied to construct treatment and control groups. These techniques use econometric methodologies such as (i) Difference-in-difference method, (ii) Reflexive comparisons, (iii) Instrumental variables methods, and (iv) Matching methods to generate comparison groups that are similar to the treatment group with respect to the observed characteristics (Heckman *et al.,* 1998; Baker, 2000; Khandker *et al.,* 2010).

2.7.1 Difference-in-difference method

This method compares the outcome in recipients of an intervention and that in the control group before an intervention has been implemented. This difference is referred to as the "first difference' because it captures the difference in outcomes for the treatment and control groups prior to the implementation (Baker, 2000). While the "second difference" is the difference in outcomes between the treatment and control groups after the project has been implemented. Therefore, the effect of a project or policy intervention in this method is the second difference less the first difference. This method requires the researcher to collect baseline data before an intervention (Baker, 2000). Therefore, this method could not be used in the current study due to lack of baseline data.

Nyang'au *et al.,* (2018) used the difference-in-difference method to evaluate the effect of Integrated Pest Management method on food security. The results indicated that Integrated Pest Management technology had positively impacted the per capita calorie intake, hence farmers who used the technology benefited from income gains. Although food access did not improve, it

improved on the economic availability of food. The study is similar to the current one in terms of effect consideration. However, the two studies differ in terms of the methodological approach, sample size, outcome variable and locality of the area of study.

2.7.2 Reflexive comparison method

This method constructs a comparison group based on the characteristics of individuals prior to their involvement in the policy or project intervention under study. Thus, it involves comparing participants to themselves before and after their involvement. This method is advantageous in that it makes it possible to evaluate policies that cover the entire population, not just the sub-groups (Rosenbaum & Rubin, 1983). The main shortcoming of this method which made it unsuitable for the current study is that, the variations in the state of affairs of a population before and after the execution of a policy may be linked to various other factors independent from the policy itself (Baker, 2000).

Ecker (2017) used the reflexive comparison method to examine the effect of interview location with homeless and vulnerably housed individuals on the quality of responses. The study provides insights into the challenges, benefits, and power relations involved in selecting a research interview site and in conducting interviews. Results demonstrated that interview locations hold great amounts of power and can provide the opportunity for holistic understandings of research topics.

2.7.3 Instrumental variable method

This method involves identifying the exogenous variation in the outcome variable of interest attributable to the program, policy or project, recognizing that its placement is not random but purposive (Heckman *et al.,* 1998). The instrumental variables are first used to predict participation in the project (simulating who would have been in the treatment and control group if the receipt of the intervention was based on that factors) (Khandker *et al.,* 2010). Then observation is made on how the outcome indicator varies with the predicted values. The difference in outcome between the simulated treatment and control groups is the effect of the program (Baker, 2000).

In this technique, selection bias on the unobserved features is corrected by finding a variable that is correlated with participation but not correlated with unobserved features influencing the outcome (Baker, 2000). To account for potential heterogeneity in milk processing participation decision and unobservable farm and household attributes, the current study combined the IV approach with an Endogenous Switching Regression Model to estimate the effect of participation in milk processing on profitability of the dairy enterprise.

Cawley *et al.,* (2018) used the instrumental variable approach to evaluate the effect of extension services on farm-level income. Distance to local advisory office and a policy change were chosen as instruments for extension participation. The results show that participation significantly increased farm income and that OLS estimates underestimated the effect. Therefore, a superior estimate of the effect was achieved which can be leveraged to better support accurate policy making.

2.7.4 Regression discontinuity method

This technique is appropriate in outcome assessment circumstances whereby the program has a continuous index with a distinct cut-off based on which the treatment and control group individuals are carefully selected (Imbens & Lemieux, 2008). The index in question must be capable of permitting for ranking of the target population because the ranks within the cut-off point are used in forming the counterfactual. Therefore, to evaluate the effect of an intervention this technique matches the non-participants with the participants who are close to the cut-off. The individuals who are just below the cut-off point have comparable features with those just above the point of cut-off (D. S. Lee & Lemieux, 2010).

Filmer and Schady (2009) analyzed the effect of a scholarship program on school enrollment, selection, and test scores using a sharp regression discontinuity design (RDD). The data used included the composite dropout risk scores, mathematics and vocabulary test scores, and a household survey. The cut-off score varied by school size, and the estimates were weighted averages. The sample used in the analysis consisted of children within a ten-point bandwidth range around the cut-off score. The results showed that school enrollment, years of schooling and attendance had improved while educational expenses paid by the family rose due to the scholarships. The actual program effect was likely to be higher since recipients were, on average, poorer than non-recipients. No significant effect on learning outcomes were found. However, recipients had better knowledge of HIV/AIDS, and the program had a positive effect on the recipients' mental health.

2.7.5 Propensity Score Matching (PSM) method

The PSM is a non-experimental method that is used in situations where constructing a counterfactual is difficult, particularly in scenarios where reliable baseline data does not exist. The PSM involves two steps, whereby a probability model is estimated in the first step to obtain the observable covariates or the propensity scores that determine project participation. In the second step, households or individuals in the treated group having similar propensity scores to those in the control group are matched (Caliendo and Kopeining, 2008). PSM was however unsuitable for the current study due to its shortcoming of inability to account for unobservable factors, resulting in biased estimates (it presents the problem of sample selection bias or auto-selection bias) (Caliendo and Kopeining, 2008) which comes about when the selected sample is not representative of the population of interest and therefore one cannot make inference based on such a sample, meaning that the sampling procedure was biased (Heckman *et al*., 1998).

Wainaina *et al.,* (2014) used PSM to assess the effect of poultry contractual farming on farm income in Nakuru County. Results indicated that engaging in contract farming positively impacted the net income earned by the participating households and hence improved the farmers' welfare. The study is similar to the current one in that they both use cross-sectional data. However, the two studies differ in terms of the sample size used, estimation method, area of study and the enterprise of interest. Whereby, Wainaina et al., (2014) focused livestock-poultry farming while the enterprise in the current study was dairy farming.

Kirui *et al.,* (2013) assessed the effect of money transfer services in the Kenyan agricultural sector. The study made use of descriptive analysis to assess the awareness and a logit, a negative binomial and PSM to examine the particular factors influencing the use, the intensity of use of the mobile phone-based money transfer services and its effect on per capita input use and income of smallholder farmers. The findings of the study showed that education, distance to banks, membership to farmer organizations, distance to the mobile phone-based money transfer agent and ownership of the financial assets affected the probability of using the mobile phone-based money transfer services. The study is similar to the current one in that they both use cross-sectional data. However, the two studies differ in terms of the outcome variable, estimation method used, sample size and the technology being disseminated to the farmers.

Rovere *et al.,* (2009) evaluated the effect of hill maize research project in Mexico and Nepal. The study used a probit model to assess the factors determining farmers' participation in the hill maize project. While the PSM technique was applied to evaluate the project's effect using a sample size of 8,000 farmers. The study established that the maize project improved the livelihoods of farmers in terms of increased food security. However, the effect of the project had more potential in Nepal than in Mexico. This was attributed to Nepal having community-based maize multiplication farmer groups in the districts, which increased the number of participants. The current study, however, differs from the Rovere *et al.,* (2009) study in sample size, estimation method, countries of study and the outcome variable.

Gebregziabher & Namara, (2007) assessed the effect of an irrigation project on poverty in Ethiopia using the PSM approach. The study's sample size was 613 households consisting of 331 irrigating and 282 non-irrigating households. The results of the study showed that irrigating households had a significantly higher average income as compared to non-irrigating households. The study concluded that irrigation had a positive effect on the agricultural yields, which led to gains in income thus reducing poverty levels among the irrigating households. Therefore, the irrigation project could be used by the Tigray government as a poverty reduction tool. The study is similar to the current one in terms of type of data used. However, the two studies differ in terms of the outcome variable, estimation method, sample size, countries of study and the product being produced by farmers.

2.7.6 Endogenous Switching Regression (ESR) method

ESR was developed by Lee, (1997). This method treats selectivity as an omitted variable problem thus accounting for selection bias (Heckman, 1979). As compared to the Heckman model, in using ESR farm outcomes like gross margins and income can be observed for all participants and non-participants in the sample. Therefore, in the ESR approach, in order to capture the differential responses of the participant and non-participant groups, respondents are partitioned to create a clear control and treatment group (Heckman, 1979). Given the interest of this study in examining the factors influencing farmer participation, as well as the effect of participating in milk processing (MP), this study employed the ESR model combined with an instrumental variable for identifying the selection equation to account for selectivity bias.

When households are not randomly exposed to a treatment, they either self-select for treatment or the technologies (treatment) are directed to the targeted households (Alene et al., 2008). Hence, participation in milk processing is potentially endogenous. Failure to account for this selection bias as well as endogeneity might potentially obscure the true effect of the dairy plant. The endogenous switching regression method addresses the selection and endogeneity problems by estimating a simultaneous equations model with endogenous switching using full information maximum likelihood (Lokshin & Sajaia, 2004). Thus, through modeling both selection and outcome equations, ESR accounts for selection bias arising from unobserved characteristics, controls for structural differences between participants and the non-participants regarding the outcome functions (Alene et al., 2008).

Kanburi Bidzakin et al., (2019) assessed the effect of rice contract farming on farm performance. The study used both ESR and PSM estimation methods. The results showed the presence of a positive and significant relationship between contract farming and yield as well as on gross margin. This study is similar to the current one in that, they both use cross-sectional data as well as the estimation method used (ESR). However, the two studies differ in terms of the outcome variable, sample size, area of study as well as the enterprise in question, as Bidzakin *et al.,* (2019), focused on rice contract farming while the enterprise in the current study was dairy farming.

Faye et al., (2018) assessed the effect of better-quality pearl millet varieties on the productivity of rural households in Senegal. The study used ESR and PSM estimation methods to control for unobserved as well as observed heterogeneity. The findings showed that the adoption of better-

quality pearl millet varieties had positively impacted farmers' yields. This study is similar to the current one in that, they both use cross-sectional data as well as the estimation method used (ESR). However, the two studies differ in terms of the outcome variable, sample size and sampling techniques applied, the farm enterprise in question, which is millet farming while the enterprise in the current study was dairy farming.

Ahmed & Mesfin, (2017) assessed the effect of agricultural cooperative membership on the wellbeing (consumption per adult) of smallholder farmers in Eastern Ethiopia. The study used ESR and PSM estimation techniques to control for selection bias and unobserved heterogeneity. The results showed that joining agricultural cooperatives had a positive effect on the wellbeing of the smallholder farmers. This study is similar to the current one in that, they both use cross-sectional data as well as the estimation method used (ESR). However, the two studies differ in terms of sample size, the outcome variable, area of study as well as sampling techniques used.

2.8 Summary of reviewed studies

From the previous studies reviewed, for instance; Manda *et al.,* (2021), Mmbando (2014), Mwambi *et al.,* (2016), Phong Tuan (2012), their results indicate that socio-economic and institutional factors such as endowment with financial and physical assets, group membership, age, experience in the enterprise, education level, having other sources of income, access to credit services and extension services either positively or negatively influenced the farmers' decision to participate in projects. PSM approach has been used in many outcome assessment studies.

However, its limitation lies in its strong assumption of confoundedness or Conditional Independence Assumption (CIA).

The confoundedness assumption implies that selection into the treatment group is solely based on observable characteristics. For valid and reliable results, the CIA assumption must be met (Caliendo and Kopeinig, 2008). Therefore, this study applied the ESR model combined with an instrumental variable for identifying the selection equation to evaluate the effect of participation in milk processing on gross profit from the dairy enterprise among smallholder farmers in Kikima Dairy Cooperative Society in Makueni County.

2.9 Theoretical framework

The study was informed by two theories; i) the random utility theory and ii) the theory of change.

2.9.1 Random Utility Theory

The random utility theory which was developed by Thurstone (1927). According to this framework, the farmer's objective is to maximize utility. A household is assumed to maximize a welfare-enhancing factor which is the utility. Therefore, a farmer's decision to participate or not to participate is grounded on the utility they are likely to derive, with an assumption that farmers are risk-neutral. An individual is assumed to maximize his/her utility from a given project if the utility derived from participating in that project is greater than the utility derived from participating in an alternative project.

The utility that an individual derives from participating in a given project is presumed to be influenced by the project's attributes and the attributes of the individual (Maddala *et al.,* 2001). However, these attributes might be perceived differently by different agents, whose socio-economic characteristics will as well affect or influence utility. As a result, an individual may perhaps not select what appears to the analyst as the ideal alternative. To explain such deviations in project choice, an arbitrary element, ε, is incorporated as a part of the participants' group utility function (McFadden, 1974).

Dairy farmers were therefore, assumed to settle for the milk buyer(s) providing them with maximum utility (Abdulai and Huffman, 2014). Under the assumptions that the utility (gross

profit) farmers derive from milk processing (MP) participation is Y_jMP, and the utility from non-participation is represented as Y_jNMP.

The two groups can be specified as:

$$YjMP = X_j\beta MP + U_jMP \quad \text{.....(1)}$$

$$Y_jNMP = X_j\beta NMP + U_jNMP \quad \text{.....(2)}$$

Where X_j is a vector of independent factors of the household, institutional and farm characteristics; βMP and βNMP respectively represent the parameter estimates for MP and NMP; U_jMP and U_jNMP are the error terms, which are Independent and Identically Distributed (IID). Therefore, a rational farmer will participate in milk processing if he or she gets maximum utility from participation and vice versa. This can be expressed as Y_jMP > Y_jNMP (Pitt, 1983).

From the empirical data, some farmer attributes are observable. However, other attributes such as the perceived net benefit(s) of participating in milk processing are not known or revealed to the researcher. In this scenario, the perceived benefits derived from participating in milk processing can be represented by a latent variable D_J*, which can be expressed in a latent variable model as a function of the observed attributes and characteristics, denoted as Z, as follows:

$$D_j^* = Z_J\gamma + \varepsilon_J;\ D_j^* = 1 \text{ if } D_J > 0;\ D_J^* = 0 \text{ if } D_J \leq 0 \quad \text{.....(3)}$$

D_J is a dummy variable that equals one for farmers who participated in milk processing and zero for non-participants. While γ is the parameter being estimated. A rational farmer who is utility-maximizing is expected to participate in milk processing if the perceived net benefits of participation are more than those of not participating. The error term ε, captures any measurement errors and the factors which were known to the respondent but unobserved by the researcher. Z represents the factors influencing participation (Pitt, 1983).

2.9.2 Theory of change

The theory of change as developed by Weiss (1995, 1998) shows a model of linking program inputs and activities that lead to observed outcomes (Rogers *et al.,* 2000; Rogers, 2014). Rogers (2008) points out that in this theory, there is need to include the context of the program under evaluation and characteristics of the participants. In the milk processing project, the inputs include services by the milk processing plant to dairy farmers while the expected outputs include higher milk production and increased income for the dairy enterprise.

In the microeconomic theory of welfare, each farmer will attempt to maximize welfare W_i and this will depend on the bundles of goods available at a given time c_i such that;

$W_i = w_i\ (c_i)$ 3.1

Where W_i is the individual welfare function. However, the same bundle of goods has different welfare levels for different individuals' depending on observable characteristics vector x, such as age, marital status, farming experience and education.

$W_i = w_i\ (c_i; x_i)$…… 3.2

Theoretically, if we have bundle of goods c_i and observable characteristics x_i then we can obtain W_i. However, sometimes bundles of goods c_i may not be fully observed due to some complexities. Then, the level of welfare achieved by an individual, can be measured according to the availability of resources, r_i to the i[th] individual and their capabilities;

$W_i = w[c_i^*(r_i); x_i] = w(\ r_i; x_i)$ ……...……3.3

where c_i^* (bundle of goods) will depend on resources r_i available . As pointed out by Jena *et al.* (2012) the bundle of goods c_i^* specified by the society are not the same as observable goods c_i observed for an individual because of diverse preferences. Individuals will choose bundles of goods that will improve their welfare. Milk processing is an opportunity which individuals can take up to achieve expected outcomes. In this theory milk processing introduced as a proxy resource r_i with the aim of increasing individual`s welfare W_i and rewritten as;

$W_i = w[c_i^*(r_i); x_i] = w(c_i^*(\ T_i; x_i)$ …….. 3.4

where T_i represents is a dummy variable for MP; i=1 for participants (treatment group) and i=0 for non-participants (control group).

Individual welfare, w_i, was measured as the total milk income and of each individual household as a function of household characteristics, participation in milk processing and error term.

$w_i = (Y_i = \beta_i X_i + \gamma T_i + \varepsilon_i)$ …… 3.5

Then the regression equation is estimated as follows:

$$Y_{it} = \beta_i X_i + \gamma T_i + \varepsilon_i \quad \text{.....3.6}$$

Where Y_{it} a binary outcome variable of interests, i.e ., Y_{i1} for participants and Y_{i0} for non-user. X_i are household, farm characteristics and institutional characteristics, T_i is a binary variable for milk processing participation and ε_i, the error term.

CHAPTER THREE: METHODOLOGY

3.1 Study area

The study was conducted in Makueni County. The county was selected purposively because it hosts the milk processing plant of interest in this study. The County is characterized by two rainy seasons, whereby the short rains occur in November-December while the long rains occur in March-April. The hilly parts of Mbooni sub-county where the Kikima milk processing plant is located receive approximately 800 - 1200mm of rainfall per annum. This level of rainfall makes the sub-county suitable for horticulture, fodder production and dairy farming. Thirty-five percent of the households in Mbooni sub-county produce and sell milk (Mutavi. et al., 2018).

Data were collected from dairy farmers in Mbooni and Kilome sub-counties of Makueni County, as shown in Figure 3.1. Makueni County is found in the eastern region of Kenya. The County borders several counties; Taita Taveta County to the South, Kajiado County to the West, Machakos County to the North, and Kitui County to the East. The county covers an area of 8,034.7 Km^2 with seventy-four percent of the total land area in this county being arable (KNBS, 2019). Most of the land has been put into agricultural use as the majority of the population in this County depends on agribusiness for their livelihood (Kenya National Bureau of Statistics, 2019). The population in this County is estimated at 884,253 persons as per the 2019 Kenya National Population and Housing Census.

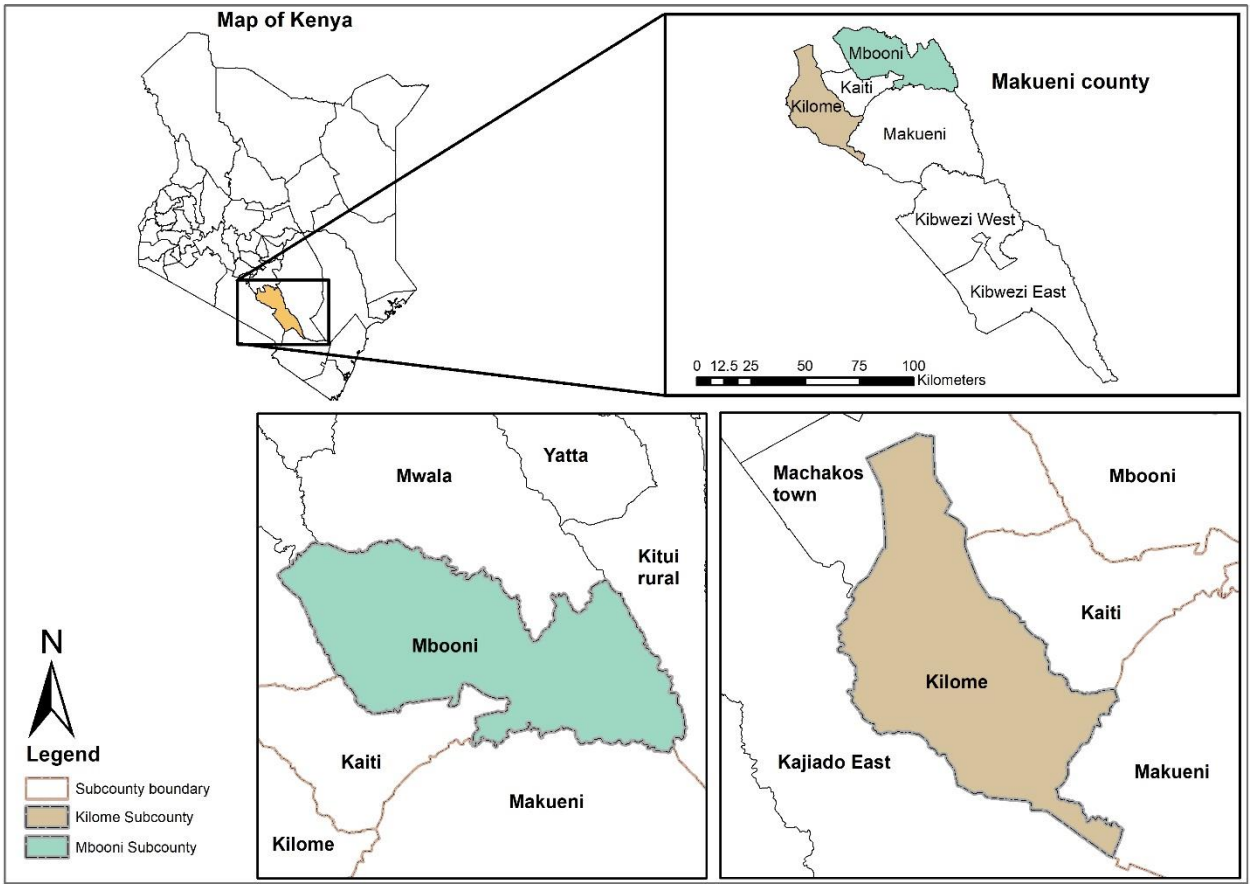

Figure 3.1: Map of the study sites (Mbooni and Kilome sub-counties) in Makueni county

Source: Created from Arc-GIS by Author

Kikima dairy cooperative society plant is located at Kikima shopping center in Mbooni Sub-county of Makueni County. Majority of the smallholder farmers who deliver their milk to this plant are from within Mbooni sub-county, with very few farmers from the neighboring regions of Kaiti sub-county, Makueni sub-county, Mwala and Machakos delivering their milk to the plant (Kikima Dairy Plant Annual Review Report, 2020). The control group respondents were drawn from the neighboring Sub-county of Kilome. Kilome and Mbooni Sub-counties are separated geographically by two other sub-counties namely; Kaiti and Makueni sub-counties.

3.2 Conceptual framework

Farmers' decision to participate in milk processing was hypothesized to be influenced by the farmers' socio-economic, farm, and institutional characteristics like education level in terms of years of formal schooling of the household head, age of the household head, farming as the primary occupation of the household head in terms of whether the household has off-farm income or is fully dependent on farming as the main source of income, sex of the household head, household size in terms of number of people who are dependent on the household head for food including the household head, experience of the of the household head in dairy farming, farm size in terms of hectares of land under fodder or set aside for grazing purposes, distanced to the main road from the farm, price of milk per litre in the year 2019, access to dairy farming extension services in terms of number of times a dairy farmer was visited by a dairy extension service provider, credit access for use in the dairy enterprise and group membership. The respective farmers' socio-economic, farm and institutional characteristics also condition the effect on welfare as shown on Figure 3.2.

The milk processing plant is expected to provide farmers with a ready market for raw milk. Similarly, since the processing of milk has the potential to enhance shelf life and retail price of milk (FAO, 2017), this is expected to have a positive effect on the welfare of the dairy farmers in terms of profits realized from the dairy enterprise, farm income, improved household income, improved food and nutrition security, poverty reduction as well as improved natural resource base. Although, all the above listed welfare indicators are important, the current study focused on profits realized from the dairy enterprise as the only welfare indicator.

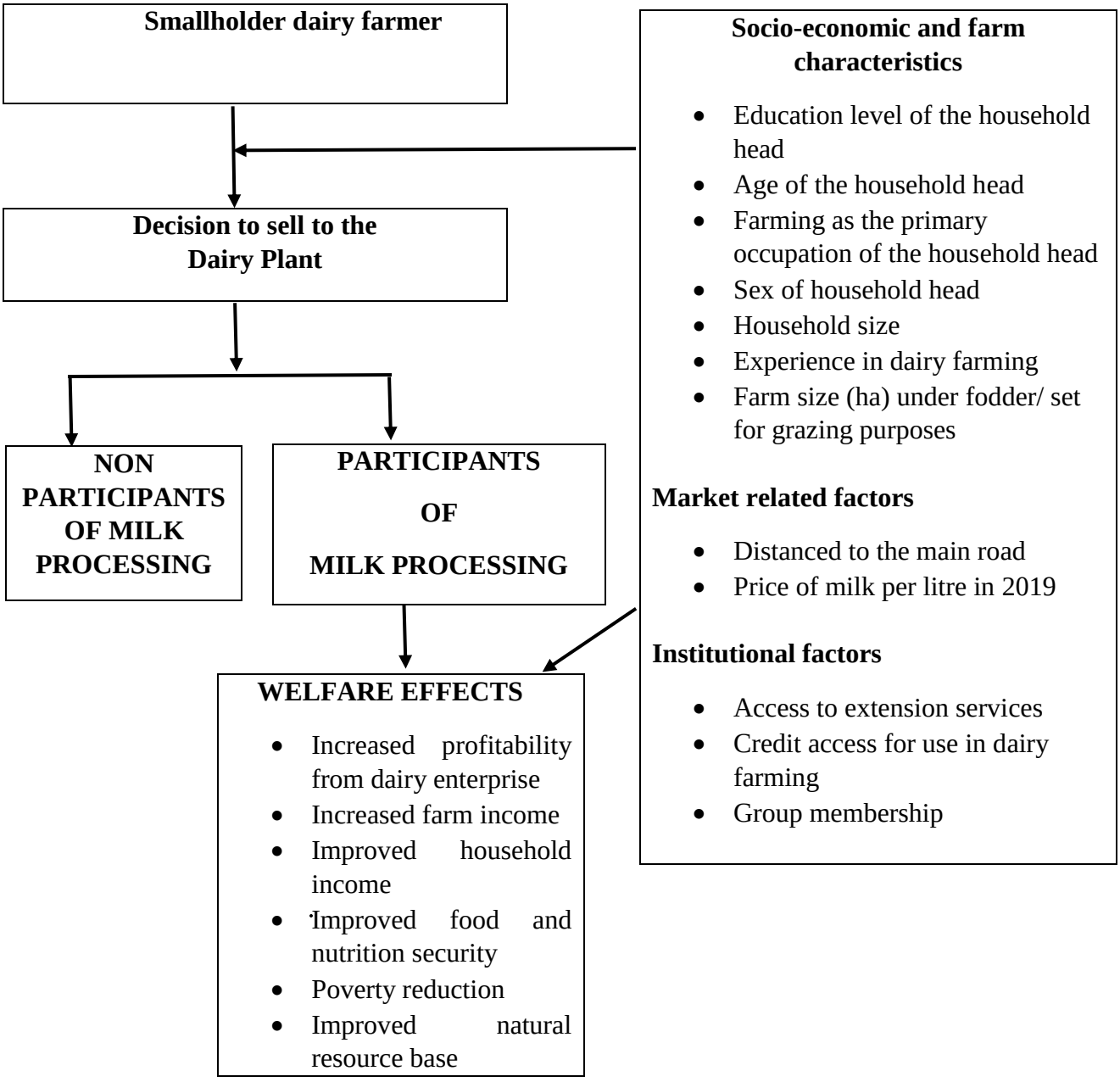

Figure 3.2: Illustration of farmers' motivation to participate in milk processing and implications on welfare

Source: Author's own conceptualization.

3.3 Sample size determination

The samples size for this study was determined using the Cochran formula. This formula is specified as:

$$n = \frac{Z^2 pq}{e^2} \quad \text{.....(4)}$$

Where *n* is the sample size being determined, *Z* is the critical value of the standard normal distribution for the desired confidence level taken as 95 percent, which is 1.96, *P* is the proportion of the target population of interest, which is 0.13 according to the Makueni County climate risk profiling report (MoALF, 2019). This represents the proportion of dairy farmers in Makueni County that sell their milk to Kikima dairy cooperative society plant. While q is 1– p. *e* is the allowable margin or desired level of precision set at 5%. According to Barlett et al., (2001), generally the acceptable margin of error or desired level of precision for educational and social researches is 5% or 0.05. Therefore;

$$n = \frac{(1.96)^2(0.13)(1-0.13)}{0.05^2} \quad \text{.....(5)}$$

$$= 174$$

To cater for non-response and incomplete questionnaires, data were collected from 200 respondents, consisting of 100 participants and 100 non-participants.

3.4 Sampling procedure

Data were collected from a survey of dairy farmers in Mbooni and Kilome sub-counties of Makueni County. This study adopted a multistage sampling technique to obtain its respondents. In the first

stage, Makueni County was purposively selected. This is due to the fact that the dairy plant is located in Makueni County serving the dairy farmers in this county. The county has six sub-counties namely; Kibwezi East, Kibwezi West, Kilome, Kaiti, Makueni and Mbooni. A good portion of smallholder farmers from Mbooni, Makueni and Kaiti sub-counties were selling their milk to the dairy plant (Kikima Dairy Plant Annual Review Report, 2020).

In the second stage, Mbooni and Kilome sub-counties were purposively selected as the regions from which the treated and control group respondents were to be drawn from respectively. Mbooni sub-county was preferred to the other two sub-counties (Makueni and Kaiti) because after examining the database of farmers selling milk to Kikima dairy plant, it was discovered that, there were critical inconsistencies in delivering milk to the plant by farmers from Makueni and Kaiti sub-counties. Therefore, it was preferred to have the treated group respondents drawn from Mbooni sub-county. While Kilome sub-county was preferred as the region from which to draw the control group respondents because it has been found to have favourable weather conditions for fodder production, similar to the weather conditions in Mbooni sub-county where the dairy plant operates. Twenty-eight percent of the households in Kilome sub-county have also been found to practice dairy farming (MoALF, 2019).

In the third stage, respondents were stratified by participation to form two strata: one comprising of participants and the other comprising non-participants. Whereby, a list of all farmers who have been selling their milk to the dairy plant consistently for the last three years was obtained from the plants' database. This list formed the sampling frame for the project participants, which consisted

of 350 farmers. While for the non-participants, a list of registered dairy farmer groups and their members, within Kilome sub-county was obtained from the county governments' department of cooperatives. To ensure the treated group was comparable with the control group, only farmers who had been practicing commercial dairy farming for more than three years were considered fit for the control group. This list formed the sampling frame for the project non-participants, which consisted of 250 farmers.

In the fourth stage, respondents were randomly selected from each sampling frame using random numbers which were generated using Microsoft Excel, to generate a sub-sample of 100 participants and 100 non-participants who constituted the actual number of respondents who were interviewed eventually.

3.5 Data types, collection methods and analysis

This study used primary cross-sectional data collected through personal interviews using a pre-tested, semi-structured questionnaire. This data were analyzed using STATA Version 14 after undergoing cleaning to ensure there were no outliers. The analysis included descriptive and econometric modeling.

Semi-structured questionnaires were used for collecting primary data. The questionnaire had six major sections. The first section had questions on household identification, while the second one had questions on household socio-economic characteristics. The third segment had questions on

household farm characteristics, the fourth section comprised of questions on market access. The fifth segment constituted of questions touching on farm profitability aspect, while the sixth section had questions on institutional factors such as social capital and extension services.

3.6 Empirical data analysis

3.6.1 Describing the socio-economic, farm, and institutional characteristics of participants and non-participants in milk processing

Descriptive statistics such as tables, percentages, frequencies, mean and standard deviations were used to generate a summary of the farmers' social-economic, farm and institutional characteristics. Independent t-tests were computed to determine the statistical differences between the averages of milk processing participants and non-participants.

3.6.2 Assessing milk production profitability among participants and non-participants in milk processing

To analyze the costs and benefits associated with dairy production amongst smallholder dairy farmers, gross margin analysis was applied to compute revenues against the variable production costs of farmers participating in milk processing and those who do not participate in milk processing. Following Giles (1962), the empirical notation applied in calculating the gross margin is as specified in Equation (4);

$$GM = P_i Y_i - R_i C_i \quad \ldots\ldots(6)$$

Where:

GM = Gross margin per dairy cow per annum $P_i Y_i$ = Total revenue

P_i = Price of milk per litre Y_i = Quantity of milk sold in litres

R_i C_i = Total variable cost R_i = Price of variable input *i* used

C_i = Quantity of input *i* the variable input used

Total variable cost $= X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7$ .....(7)

Where: (values are in Kenya shillings)

X_1 = Cost of fodder X_6 = Cost of commercial feeds

X_2 = Cost of veterinary services X_7 = Cost of mineral supplements

X_3 = Labor cost (wages for casual workers)

X_4 = Transportation costs

X_5 = Other variable costs (such as cleaning costs, repair and maintenance costs)

The difference of statistical means as developed by Gosset (1908) was used to test whether there was a significant difference in the gross profit realized by participants and non-participants. The t-values for the comparison of means are estimated as follows;

$$t = \frac{X_1 - X_2}{\sqrt{\frac{(S_1{}^2)}{n_1} + \frac{(S_2{}^2)}{n_2}}} \quad \text{.....(8)}$$

Where:

X_1 = Mean gross profit (Kshs) for participants

X_2 = Mean gross profit (Kshs) for non-participants

$S_1{}^2$ = Sample variance for participants

$S_2{}^2$ = Sample variance for non-participants

n_1 = Number of participants

n_2 = Number of non-participants

3.6.3 Assessing determinants of participation in milk processing

To analyze factors determining participation in milk processing, a probit model was used. The probit model has a basic assumption that the error term is normally distributed. The probit model was preferred over logit owing to its normal distribution as compared to logit's logistic distribution (Berry et al., 2010). Additionally, the probit model was found to best fit the data as per Jacque Bera's test of normality. In this study, a participant of milk processing refers to a dairy farmer who have been selling their milk to the dairy plant consistently for the last three years. It is assumed that there is a latent variable P_i* which represents the participation status, which can be expressed as;

$$P_i* = \alpha Zi + \varepsilon; \ldots\ldots (9)$$

Where:

$$\text{Pi} = \begin{cases} 1 \; if \; \text{P}i * > 0 \\ 0 \; if \; \text{P}i \leq 0 \end{cases} \ldots\ldots (10)$$

Where α is a vector of unknown parameters to be estimated, Z_i represents a vector of exogenous variables and ε is the error term that is normally distributed. The probability that an individual belongs to a certain group is expressed as:

$$\Pr\,(Pi = 1|Zi) =, for \; i = 0, 1 \ldots\ldots (11)$$

The parameter estimates obtained from the probit model simply point out the direction of the effect of the independent variables on the dependent variable. In order to establish the extent of the change in the explained variable as result of a unit change in an independent variable, the marginal effects of the explanatory variables were computed as:

$$((Pi = 1|Zi))/\,\partial Zi = (\partial E(Pi|Zi))/\,\partial Zi = \varphi(Zi'\beta)\beta \ldots\ldots (12)$$

The regression model as applied in this study was empirically estimated as shown in Equation (11);

$$Y_i = \beta_o + \beta_1 X_{1i} + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \varepsilon$$

……..(13)

The variables hypothesized to influence smallholder farmers' decision to participate in milk processing and their expected signs are as presented in Table 3.1;

Table 3.1: Variable definitions and hypothesized signs for the determinants of participation

Variable	Description	Measurement	Expected sign
Sex (X_1)	Sex of the household head	Dummy (male = 1, female = 0)	+
Education (X_2)	Education of the household head	Years of formal schooling	+
Age (X_3)	Age of the household head	Age in years	+
Farming as primary occupation (X_4)	The main occupation of the household head	Dummy specified as: farming =1, otherwise = 0	+
Experience (X_5)	Experience in dairy farming	Years	+
HHsize (X_6)	Household size	The number of people dependent on the household head for food	+
Farm size (X_7)	Size of the plot owned by the farmer	Hectares	+
Credit (X_8)	Access to credit for use in the dairy enterprise	Dummy (Yes = 1, otherwise = 0)	+
Distance (X_9)	Distance in kilometres from the farm to the road	Measured in kilometres (Km)	-
Extension (X_{10})	Access to extension services on dairy management practices in the year 2019	Number of times the farmer was visited by an extension service provider	+
Gmember (X_{11})	Group membership of the household head	Dummy (Belongs to a farmer group =1, otherwise =0)	+

Source: Author's own conceptualization.

Sex of the household head (Sex): According to La Rovere et al., (2009), households headed by men have a greater likelihood of taking part in new projects. This is probably because men have been found to be the principal decision makers particularly on matters involving participation in agribusiness projects such as cooperative membership and milk processing. Whereas according to Regassa & Stoecker, (2012), female-led families are more likely to take part in agribusiness projects such as milk processing because they are more vulnerable to food insecurity as compared to male-headed families. In this research study, the sex of the household head was hypothesized to influence participation in the project positively, with households headed by men having been expected to have a higher probability of participating.

Education level of the household head (Education): In this study, education level was quantified as the number of years the household head has spent in formal schooling. Household heads having a higher education level were expected to be well aware of output prices and marketing channels as compared to those with a lower level of education and were therefore likely to participate in milk processing as cooperative members (Muricho, 2017). This study hypothesized that the higher education level of the household head would positively influence participation.

Age of the household head (Age): In this research study, age was quantified as the number of years of the household head. A number of the studies done in the past reported existence of an inverse relationship between the age of the household head and participation in agribusiness projects such as cooperative membership and milk processing (Davis et al., 2012). This is

attributable to old farmers being considered as being more risk-averse, whereas young farmers are considered to be moderately less risk-averse. Other studies claim that older farmers are likely to take part in new projects because they have more experience, with essential resources (for instance: capital) therefore are less risk-averse (Pattanayak et al., 2003). This research study hypothesized that the age of the household head would influence participation positively.

Farming as the main occupation of the household head (Occupation): According to Wainaina et al., (2014), farming as the main occupation has a significant influence on the decision to take part in agribusiness projects such as milk processing and cooperative membership. Whereby, farmers with off-farm employment (for instance: salaried, business) in Nakuru, Kenya were found to be more likely to participate in agribusiness projects as compared to those who relied on farming as their main occupation. This research study hypothesized that off-farm income would positively influence farmers participation in the milk processing project.

Experience in dairy farming (Experience): According to Davis et al., (2012), the experience a farmer has, affects their ability to understand the objectives any agribusiness project such as milk processing. Therefore, farmers with higher level of experience in a given farming enterprise are more likely to participate. This research study hypothesized that the experience of the household head in dairy farming would positively influence participation.

Household size (HHsize): In this research study, household size was measured in terms of the number of individuals existing at the household during the survey period and who have been cooking, sharing meals and staying together. A large household size influences involvement in agribusiness projects positively because having many people in a given household is perceived as a source of cheap labour, making it easier and cheap to discharge labour intensive activities accompanying agribusiness projects (Davis et al., 2012). Whereas according to Muhammad et al., (2011), having a large sized household was found to intensify family expenses hence being less likely to take part in agribusiness projects. This research study hypothesized that the size of a household would influence participation in milk processing positively.

Farm size (Farm size): This study hypothesized that farm size would positively influence participation in milk processing. This is because farmers with a large piece of land are more likely to try different agribusiness projects since they can easily afford to set aside a section of their land for that purpose as opposed to those with smaller farm size (Uaiene et al., 2009). According to the research findings by Olwande *et al.,* (2015), farm size can be regarded as a measure of wealth. Therefore, as the farm size increases, the probability of trying or participating in new agribusiness projects increases as well.

Milk price (Mprice): In this research study, the price of milk was quantified in Kenya shillings per litre of milk as offered in the year 2019. Farmers have been found to target marketing channels that offer a relatively higher price, as this boosts their income levels (Olwande et al., 2015). This research study hypothesized that price would positively influence a farmer's decision to participate

in milk processing. However, from the empirical data, the price of milk offered by the plant to the participants was not varying as all participants received the same amount per litre of milk in the year 2019. Therefore, due to lack of variability, this variable was omitted in the analysis.

Access to credit (Credit): In this study, credit access was measured on the basis of a farmer being able to get credit for use in their dairy enterprise. Credit accessibility eases cash constraints that farmers may face. This therefore, heightens a farmer's capability to acquire the tools, inputs and materials needed for that specific project (dairy farming in this case). Therefore, credit access has been found to have a direct relationship with participation in agribusiness projects such as cooperative membership and milk processing (La Rovere et al., 2009). This research study hypothesized that credit access would influence a farmer's decision to participate in milk processing positively.

Distance to the road (Distance): In this research work, distance was measured as the number of kilometres a household is situated from the nearby road. Households located near tarmac roads have been reported to have a greater probability to taking part in agribusiness projects. This is because tarmac roads have been found to reduce cost of transporting farm produce to nearby markets (Davis *et al.,* (2012). This study hypothesized an inverse relationship between distance and involvement in the project.

Access to extension services (Extension): According to Olwande *et al.,* (2015) access to extension services, for instance, advisory services on better management and marketing techniques positively influence farmers' decision to take part in agribusiness such as cooperative membership. This is because having access to extension services heighten a farmer's level of understanding on matters relating to marketing alternatives, hence refining their skills in choosing amongst the existing marketing channels. This study hypothesized a positive relationship between access to extension services and a farmer's decision to participate in milk processing.

Group membership of the household head (Gmember): Group membership provides social capital which enables a farmer to overcome livelihood related shocks with ease (Yirga & Hassan, 2010). According to La Rovere et al., (2009), group membership influenced farmers' decision to participate in the hill maize research project positively. This was attributed to the fact that majority of the developmental projects initiated in this particular area were focused on working with farmer groups. Therefore, if a farmer was a member in any of the farmer groups, their probability of taking part in agribusiness projects such as milk processing was higher. This study hypothesized that group membership would positively influence participation in the project.

3.6.4 Effect of participation in milk processing on milk income among smallholder dairy farmers

The endogenous switching regression (ESR) model was used to evaluate the effect of farmers' participation in milk processing on gross profit realized by the dairy enterprise from the sale of milk. The estimation using this method proceeds in two stages. A probit regression is used in the

first stage to determine the probability of participation in milk processing. Since the farmers decide to participate or not to participate in milk processing, the observed net benefits take the following values:

Group 0 (NMP): $Y_{JNMP} = X_J \beta_{NMP} + U_{JNMP}$ if $D_J = 0$ ……(14)

and

Group 1 (MP): $Y_{JMP} = X_J \beta_{MP} + U_{JMP}$ if $D_J = 1$ ……..……..….(15)

Where Y_{JMP} and Y_{JNMP} are the outcome variables (gross profit from the dairy enterprise) for milk processing (MP) and non-milk processing (NMP) groups respectively, X_J is a vector of independent variables of household characteristics, farm, and institutional factors. The vector β in Equation (14) and Equation (15) represents the parameters that are being estimated. If self-selection occurs in milk processing (MP) participation decision, it may lead to non-zero covariance between the error terms of the outcome equation and MP participation decision equation. The error terms U_{JMP}, and U_{JNMP} are assumed to have a trivariate normal distribution with zero mean and covariance matrix as represented in Equation (16):

$$\text{Cov } (U_A \text{ and } U_N) = \sum = \begin{pmatrix} \sigma^2{}_A & \sigma_{AN} & \sigma_{A\varepsilon} \\ \sigma_{AN} & \sigma^2{}_N & \sigma_{N\varepsilon} \\ \sigma_{A\varepsilon} & \sigma_{N\varepsilon} & \sigma^2{}_\varepsilon \end{pmatrix} \text{……...…….. (16)}$$

Where; *A = MP; N = NMP*

Var $(U_A) = \sigma^2{}_A$; Var $(U_N) = \sigma^2{}_N$; Var $(\varepsilon) = \sigma^2{}_\varepsilon$

Cov $(U_A, U_N) = \sigma_{AN}$; cov $(U_A, \varepsilon) = \sigma_{A\varepsilon}$; cov $(U_{N,} \varepsilon) = \sigma_{N\varepsilon}$

For this reason, the error terms in Equation (16), conditional on the sample selection criterion, have non-zero expected values, and ordinary least squares estimates of coefficients β_{MP} and β_{NMP}

also suffer from sample selection bias (Lee, 1982). The values of the truncated error term (U_{MP} |D = 1) and (U_{NMP} |D = 0) are then given as;

$$(U_{NMP} |D = 0) = E(U_{NMP} |\varepsilon \leq -Z'Y) = \sigma_{NMP\varepsilon} \frac{\partial\left(\frac{Z'Y}{\sigma}\right)}{1-\theta\left(\frac{Z'Y}{\sigma}\right)} = \sigma_{NMP\varepsilon}\lambda_{NMP} \quad \text{.....(17)}$$

$$\text{and } (U_{MP} |D = 1) = E(U_{MP} |\varepsilon - Z'Y) = \sigma_{MP\varepsilon} \frac{\partial\left(\frac{Z'Y}{\sigma}\right)}{1-\theta\left(\frac{Z'Y}{\sigma}\right)} = \sigma_{MP\varepsilon}\lambda_{MP} \quad \text{.....(18)}$$

Where ∂ and θ are the probability density and cumulative distribution function of the standard normal distribution respectively. The ratio of ∂ and θ evaluated at $Z'Y$ represent the inverse Mills ratio λ_{MP}, λ_{NMP} which are also known as the selectivity terms (incorporated into Equations [17] and [18]) and they are useful in accounting for selection bias. Where λ_{MP} and λ_{NMP} respectively represents the inverse mills ratios for participants and nor-participants, while σ represents the covariance of the error terms. When the error term of the selection equation is correlated with the error terms of the outcome equation for the participants and non-participants, then we have a selection bias problem. Thus, estimates from the selection equation are used to compute λ_{MP} and λ_{NMP}, which are then added to the outcome equations to correct for selection bias. If $\sigma_{NMP\varepsilon}$ and $\sigma_{MP\varepsilon}$ in Equations (17) and (18) are statistically significant, endogeneity exists.

The estimates (Y) from Equation (14) are then used in calculating the selectivity terms (λ_{MP}, λ_{NMP}) according to Equations (17) and (18). This two-step approach has a limitation in that it generates heteroscedastic residuals and hence requires complex adjustments to generate consistent standard errors. To overcome this challenge, this study applied the full information maximum likelihood method (Lokshin & Sajaia, 2004). Of keen interest are the signs and significance levels

of the correlation coefficients from the estimates. In this study, both the treatment and heterogeneity effects on gross profit from the sale of milk were assessed. This is because the effect of participation in MP on gross profit of the dairy enterprise was of interest in this study. The Full Information Maximum Likelihood (FIML) estimation method which simultaneously estimates the probit criterion or selection equation and the outcome equations to yield consistent standard errors was used in estimating the ESR model owing to its efficiency in estimation (Lee & Trost, 1978).

Although the FIML ESR model is identified through non-linearities of λ_{MP} and λ_{NMP}, (Lokshin and Sajaia 2004), a better identification of the ESR model requires an exclusion restriction. That is, for the ESR model to be correctly specified, the selection equation should contain at least one selection instrument in addition to those generated by the non-linearity of the selection model correlated with milk processing participation but uncorrelated directly with gross profit from the dairy enterprise. The selection instrument used in the current study is age of the household head. The validity of the instrument was tested using falsification test. The results showed that the selected instrument could be considered as valid as it was statistically significant in explaining participation decision *[$\chi 2$ = 6.94 (p-value = 0.020*)] but is not statistically significant in explaining the gross profit function *[F = 2.11 (p-value= 0.343)]* and *[F = 1.14 (p = 0.441)]* for participants and non-participants, respectively, verifying the validity of the instrument. Therefore, age was not directly correlated with gross profit from the sale of milk, except through participation in the milk processing project. The variable Age was also statistically significant in equations pertaining the decision to participate in milk processing (Table 4.4 and Table 4.5) but not of the income (outcome) equations (Table 4.5).

3.6.4.1 Estimating heterogeneity and treatment effects on milk income

The ESR model can be used to compare the expected gross profit of farmers who chose to participate in MP as illustrated in Equation (18) and those that chose not to participate as illustrated in Equation (19). In the hypothetical counterfactual case, given that the households that participated in milk processing did not participate, the expected income is as illustrated in Equation (20). Equation (21) illustrates the hypothetical counterfactual case of the expected gross profit from the sale of milk given that the households that did not participate in milk processing participated. The conditional expectations for the outcome variables in the above four mentioned cases are as illustrated in Table 3.2. Where Equations (19) and (20) illustrate observed expected gross profit from the dairy enterprise while Equations (21) and (22) represent counterfactual expected gross profit from the dairy enterprise.

D_i = 1 if households participated in MP

D_i = 0 if households did not participate in MP

Y_{JMP} = Gross profit level from milk sales if the households participated in MP

Y_{JNMP} = Gross profit level from milk sale if the households did not participate in MP

TT = Treatment effect of milk processing on the treated (i.e.: households that participated)

TU = Treatment effect of milk processing on the untreated (i.e.: households that did not participate)

BH = represents the base heterogeneity effect of households that participated (BH_{MP}), and did not participate (BH_{NMP});

TH = TT-TU represents the transitional heterogeneity.

$$E(Y_{JMP} | D = 1) = X\beta_{JMP} + \sigma_{MP\varepsilon}\lambda_{MP} \quad \ldots\ldots(19)$$

$$E(Y_{JNMP} | D = 0) = X\beta_{JNMP} + \sigma_{NMP\varepsilon}\lambda_{NMP} \quad \ldots\ldots(20)$$

$$E(Y_{JNMP} | D = 1) = X\beta_{JMP} + \sigma_{NMP\varepsilon}\lambda_{MP} \quad \ldots\ldots(21)$$

$$E(Y_{JMP} | D = 0) = X\beta_{JNMP} + \sigma_{MP\varepsilon}\lambda_{NMP} \quad \ldots\ldots(22)$$

Equations [19] and [20] illustrate the actual expectations which were to be observed in the sample. Equations [21] and [22] illustrate the counterfactual expected outcomes. The effect of the treatment on the treated (TT) was given by the difference between Equations (19) and (21) (J. J. Heckman & Vytlacil, 2001).

$$TT = E(Y_{JMP} | D = 1) - (Y_{JNMP} | D = 1) = X(\beta_{JMP} - \beta_{JMP}) + (\sigma_{MP\varepsilon} - \sigma_{NMP\varepsilon})\lambda_{MP} \quad \ldots\ldots (23)$$

The above equation denotes the effect of participation in milk processing on the gross profit from the dairy enterprise of farmers who actually participated.

Table 3.2: Heterogeneity and treatment effects

Sub-samples	**Decision stage**		**Treatment effects**
	To participate	**Not to participate**	
Farm households that participated in MP	(19) $E(Y_{JMP} \mid D = 1)$	(21) $E(Y_{JNMP} \mid D = 1)$	TT
Farm households that did not participate	(22) $E(Y_{JMP} \mid D = 0)$	(20) $E(Y_{JNMP} \mid D = 0)$	TU
Heterogeneity effects	BH_{MP}	BH_{NMP}	TH

The effect of the treatment on the untreated (TU) for farmers that actually did not participate in MP was calculated as the difference between Equation (22) and (20).

$$TU = E\ (Y_{JMP}\ |D = 0) - (Y_{JNMP}\ |D = 0) = X\ (\beta_{JMP} - \beta_{JMP}) + (\sigma_{MP\varepsilon} - \sigma_{NMP\varepsilon})\lambda_{NMP} \ldots\ldots\ldots\ldots (24)$$

The heterogeneity effects for the treated group were obtained as the difference between Equations (19) and (22). The heterogeneity effects entail the differences in the outcome due to the inherent attributes of the respondents such as innate ability and not that of the treatment (Carter & Milon, 2005);

$$BH_{CF} = E\ (Y_{JMP}\ |D = 1) - (Y_{JMP}\ |D = 0) = \beta_{JMP}\ (X_{JMP} - X_{NJMP}) + (\lambda_{MP} - \lambda_{NMP})\sigma_{MP\varepsilon} \ldots\ldots\ldots (25)$$

The heterogeneity effects for the group that did not participate in milk processing (NMP) was given as the difference between Equation (21) and Equation (20)

$$BH_{NCF} = E\ (Y_{JNMP}\ |D = 1) - (Y_{JNMP}\ |D = 0) = \beta_{JNMP}\ (X_{JMP} - X_{NJMP}) + (\lambda_{MP} - \lambda_{NMP})\sigma_{MP\varepsilon} \ldots (26)$$

Transitional heterogeneity was given as the difference between Equations (23) and (25) (TT) and (TU). Transitional heterogeneity establishes whether the effect of participating in MP is smaller or larger for households that participated or for those households that actually did not participate in the counterfactual case that they chose to participate. The *mspredict command* on Stata follows the *movestay command* to calculate the predictive statistics (effect estimates), that is the average treatment effect on the treated (ATT), the average treatment effect on the untreated (ATU) and the heterogeneity effect (HE).

3.7 Model Diagnostic Tests

3.7.1 Test for Multicollinearity

Multicollinearity is regarded as being present when there is a correlation among the exogenous variables in a model (Daoud, 2018). The presence of multicollinearity leads to inflated standard errors and deflated t-test values, which might mislead in failing to reject the null hypothesis. For this study, a multicollinearity test was done using the Variance Inflation Factor (VIFs). If the VIF values are observed to be above 5, that is an indication of the presence of severe multicollinearity (Gujarati, 2004). To further rule out the presence of any association among the exogenous variables in the endogenous switching regression model, a partial correlation test was conducted. The partial correlation analysis tests for the presence of a linear relationship between two exogenous variables while excluding the other independent variables in a model (Baba et al., 2004).

3.7.2 Test for Heteroscedasticity

Heteroscedasticity is regarded as being present if the variance of the error term is not constant. The presence of heteroscedasticity leads the estimates being regarded as not 'efficient' and 'best' although they might be linear and unbiased (Gujarati, 2004). This means any inferences drawn from such estimates are likely to be misleading. To test for heteroscedasticity in the endogenous switching regression model, this study applied the Breusch-Pagan/Cook-Weisberg test. The presence of heteroscedasticity is ruled out if the *p*-value of the resultant chi-square from the Breusch-Pagan/Cook-Weisberg test is found to be statistically insignificant, which is an indication that the variance of the error terms is constant (Greene, 2003).

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Socio-economic and Farm Characteristics of Smallholder Dairy Farmers

The socio-economic, farm and institutional characteristics of dairy farmers in Mbooni sub-county (project participants) and Kilome sub-county (project non-participants) which constitute the surveyed households are presented in Table 4.1. The results show that, the mean annual milk income per cow, the participants realized a significantly lower average milk income per cow at Kshs 121,127.70 as compared to non-participants whose average milk income per cow was Kshs 194,932.70. The mean difference between the two groups was significantly different at 5 percent. The differences in milk income can be attributed to the higher price per litre of milk offered by other available marketing channels to the non-participants, where the non-participants sold their milk at an average price of Kshs 53.74 as compared to participants who sold their milk at an average price of Kshs 32.

The difference in the gross milk income could also be attributed to; the relatively lower average cost of fodder per annum of Kshs 493.50 as incurred by the non-participants compared to Kshs 569.31 as incurred by the participants, the lower average cost of veterinary services per annum of Kshs 2141.63 as incurred by the non-participants compared to Kshs 2251.72 as incurred by the participants, relatively lower average cost of mineral supplements of Kshs 3247.31 incurred by the non-participants compared to Kshs 4027.23 as incurred by the participants, relatively lower average cost of labour per annum of Kshs 2253.40 incurred by the non-participants compared to Kshs 4208.42 as incurred by the participants.

Table 4.1: Socio-economic and farm characteristics of smallholder dairy farmers in Mbooni and Kilome Sub-counties

Variable	*Pooled sample n = 200*			*Participants (n = 100)*	*Non-participants (n = 100)*	*Mean differences*	*t-statistic*
	Min	*Max*	*Mean (SD)*	*Mean*	*Mean*		
HH annual milk income (Kshs)	15840	1365100	228553.60(191195.3)	193331.50	263775.70	-7044.18***	2.64
Total HH annual milk income per cow (Kshs)	15840	527488	158030.20(95886.73)	121127.70	194932.70	-73805.07***	5.88
HH total annual milk production per cow (Litres)	730	16790	4038.42(2205.73)	4257.12	3819.73	437.39	1.41
Household head education (Years of formal schooling)	0	16	11.59(2.97)	11.52	11.66	-0.14	0.33
Household head experience (Years of dairy farming)	3	45	8.8(7.66)	10.63	6.97	3.66***	3.47
Household head Age (Years)	20	80	49.56(12.52)	52.56	46.55	6.01***	3.49
Farm size (Hectares)	0.125	7	1.01(0.95)	1.21	0.82	0.38***	2.87
Number of lactating cows	1	5	1.45(0.73)	1.57	1.32	0.25***	2.46
Number of breeds kept	1	2	1.05(0.21)	1.05	1.04	0.01	0.34
Distance from the farm to the road (Km)	0.01	3	0.46(0.69)	0.54	0.38	0.16	1.65
Sex of the household head (1= Male, 0= Female)	0	1	0.74(0.44)	0.71	0.76	-0.05	0.80
Access to extension services (No. of times visited by an extension officer)	0	12	2.19(2.24)	2.15	2.23	-0.08	0.25
Access to credit services (1= Yes, 0= No)	0	1	0.32(0.47)	0.31	0.32	-0.01	0.15
Membership to social groups (1= Yes, 0= No)	0	1	0.93(0.26)	0.94	0.92	0.02	0.55
Farming as HH primary occupation (1= Farmer, 0=Otherwise)	0	1	0.70(0.46)	0.63	0.76	-0.13**	2.58
Household head marital status (1= Married, 0= Otherwise)	0	1	0.87(0.34)	0.86	0.88	-0.02	0.42
Household size	2	13	5.06(1.99)	5	5.11	-0.11	0.39
Breeding method used (1= AI, 0= Otherwise)	0	1	0.87(0.34)	0.95	0.78	0.17***	3.61
Milk price per litre (Kshs)	32	60	42.87(11.42)	32	53.74	-21.74***	45.11
Total annual variable cost (Kshs)	2400	86450	17554.95(14521.58)	22281.29	12828.61	9452.68***	4.86
Total annual variable cost per cow (Kshs)	2100	64500	12370.97(8969.85)	15100.08	9641.87	5458.21***	4.51

***, **,** *** denote significance at 10 percent, 5 percent and 1 percent respectively

Source: Survey Data (2022)

The milk price per litre offered by the dairy plant was Kshs 32 as compared to an average price of Kshs 53.74 offered by other marketing channels to the non-participants. The low price per litre of milk offered by the dairy plant could be identified as the major causative factor of the high prevalence of side selling among the participants. The mean difference in milk price per litre between these two groups was statistically significant at 1 percent. The non-participants were found to be selling their milk to nearby schools, hotels, hospitals and individual households who prefer unprocessed milk and offer a higher price as compared to the dairy plant. This shows that the two sub-counties of Mbooni and Kilome are characterized by high demand for unprocessed milk in its informal sector.

The higher gross annual milk income among the non-participants would also be due to the relatively lower total annual variable cost of production and variable cost per cow on average, at Kshs 22,828.61 and Kshs 9,641.87 respectively as compared to Kshs 22,281.29 and Kshs 15,100.08 among the participants. The mean difference in total annual variable cost and annual variable cost of production per cow was significant at one percent.

The average annual milk production per cow was 4257.12 litres for participants compared to 3819.73 for non-participants. The high milk productivity per cow among the participants may be attributed to the participants having more years (ten years on average) of experience in dairy farming as compared to the non-participants who had on average six years of experience in dairy farming. Hence the participants are likely to have had a better understanding of the right management practices which are likely to enhance milk productivity of their cows.

Also, the high milk productivity among the participants could be likely due to the fact that, majority (71 percent) of the participants were keeping pure exotic breeds which are likely to have a higher level of milk productivity as compared to 51 percent of the non-participants. However, there was no significant difference in milk production per cow between the two groups. A study by Marwa, et al., (2020) had similar findings, where farmers who were members of dairy cooperative societies and participated in milk processing were found to have more years of experience in dairy farming and realized a higher level of annual milk productivity per cow as compared to farmers who were not members of dairy cooperative societies and did not participate in milk processing.

On average, the household's head total years of formal schooling, for both participants and non-participants was almost 12 years. This implies that the two groups (treated and control) are similar with respect to the education level of the household head. This high level of literacy among both groups implies that the smallholder dairy farmers in Makueni County were likely to appreciate and participate in agribusiness projects owing to their ability to synthesize new and complex information. According to Kibira et al., (2015), educated farmers are able to interpret new information better than those without education.

In relation to household head experience in dairy farming, the participants had a significantly higher experience in dairy farming on average, at 11years as compared to 7 years among the non-participants. The difference in experience between the two groups was significantly different at 1percent. This could be attributed to the high mean household head age among the participants at

53 years as compared to 47 years among non-participants, hence the reason why the participants were more experienced.

The difference in age between the two groups was significant at 1 percent. This implies that farmers in Mbooni sub-county (participants) were on average older than those in Kilome sub-county (non-participants). These findings are consistent with those of Marwa et al., (2020) who reported that farmers who participated in agribusiness projects relating to the dairy value chain had a higher level of experience in dairy farming and were more aged as compared to the non-participants.

In relation to the farm size of the plot or piece of land used for grazing or growing fodder, on average, the participants had about 1.21 hectares compared to 0.82 hectares for the non-participants. The difference in farm size between the treated and control group was statistically significant at 1 percent. This implies that farmers in Mbooni sub-county had put more land on dairy production as compared to those in Kilome sub-county.

The results further revealed that the participants had a significantly higher number of lactating cows, where on average the participants owned 2 cows compared to non-participants who on average owned one cow. Majority of the cows kept by the participants were of exotic breeds (Friesian, Guernsey, Ayrshire and Jersey) at 70 percent. Moreover, 13 percent of the participants were found to be keeping local breeds (Sahiwal, Boran and zebu) and 17 percent kept crosses. While among the non-participants, only 51 percent were found to be keeping exotic breeds, 24

percent reared local breeds and 25 percent had crosses. This could be attributed to the fact that the participants had more years of experience in dairy farming and are likely to have more information out of experience regarding the milk productivity gains associated with rearing pure exotic breeds as compared to keeping local breeds. However, the mean difference in the number of breeds kept by the farmers was not significant.

Contrary to the expectation that, the distance from the farm to the road for participants would be shorter, hence lowering cost of transport to the dairy plant, and making it easier for participants to deliver their milk compared to the non-participants. The mean distance to the road for participants was higher at 0.54 Km compared to 0.38 Km for non-participants. This would imply that non-participants were closer to the main road and thus were likely to be easily be accessed by middlemen who buy milk at the farm gate offering them a better price as compared to the participants who on average were a bit far from the main road and thus, they were likely not to be easily accessed by middlemen. However, the mean difference in distance to the road between the two groups was not statistically significant.

Seventy-one percent of participating households were male-headed compared to seventy-six percent for the non-participants. The mean difference in sex of the household head between the two groups was not statistically significant. Eighty-six percent of the participants were married compared to eighty-eight percent for the non-participants. However, the mean difference in marital status among the two groups was not statistically significant.

In relation to access to extension services, the results show that, on average every dairy farmer was visited by an extension service personnel twice a year. However, the mean difference in the number of times a farmer was visited between the two groups was not statistically significant. This would imply that the difference in yield among the participants and non-participants cannot be solely attributed to the status of extension services provision but to other factors such as experience in dairy farming, breeds of dairy cows kept, education level etc.

Moreover, the aspect of delayed payment by the dairy plant is likely to have made it difficult for farmers to secure credit from their lending social groups (table banking) using their milk proceeds as collateral. However, the average difference in credit access between the two groups was not statistically significant. This finding is contrary to the hypothesis that access to credit would have a direct relationship with project participation (Rovere *et al.*, 2009). This is also contrary to finding by Mutuku *et al.*, (2019) who reported that participation in contract farming was high among farmers who had accessed credit.

There was a difference in group membership, 94 percent of the participants were members of a social group compared to 92 percent of the non-participants. This suggests that participants were more aware of the importance of being organized into farmer groups in enhancing access to extension services and farm inputs. However, the mean difference in social group membership was not significant. This is similar to the finding by Marwa et al., (2020), who reported high membership to social groups among farmers who participated in new agricultural technologies.

In relation to farming as the occupation of the household head, on average 63 percent of the participants relied on farming as their primary occupation or main source of income, meaning these farmers did not have off-farm income, as compared to 76 percent of the non-participants. This implies that a higher proportion of the non-participants relied on farming as their main source of income and very few had off-farm income as compared to the participants. Hence the choice of selling their milk through in the informal market which offered a higher price per litre of milk compared to the dairy plant. Thus, majority of the participants had other sources of income other than farming. This is likely to be the reason why they continue to deliver their milk to the dairy plant despite experiencing delayed payments and being offered a lower price. The difference in primary occupation between the two groups was statistically significant at 5 percent. This finding is consistent with those of Wainaina et al., (2014) and Mutuku *et al.*, (2019), who reported a higher prevalence of off-farm income among project participants.

On average 95 percent of the participants were found to have adopted Artificial Insemination (AI) as their breeding method compared to only 78 percent for the non-participants. The mean difference in the breeding method used by the farmers was statistically significant at 1 percent. The higher adoption of AI breeding method among the participants could be due to the higher prevalence of off-farm income hence farmers could easily afford to pay for the service. There were differences in household size between the participants and non-participants. However, the mean difference in household size between the two groups was not statistically significant.

4.2 Profitability of milk production among smallholder dairy farmers

The results show that both participants and non-participants were operating profitably, with the non-participants recording a higher annual gross margin per cow at Kshs 194,932.73 compared to Kshs 121,127.62 for the participants, as shown in Table 4.2.

Table 4.2: Profitability analysis for participants (treated) and non-participants (control)

Category	Total Revenue (Kshs/Cow/Annum)	Total Variable Cost (Kshs/Cow/Annum)	Annual Gross Margin (Kshs/Cow/Annum)
Participants			
Mean	136 227.70	15 100.08	**121 127.62**
Std. Deviation	80 824.85	10 628.47	
Minimum	35 040	2 100	
Maximum	537 280	64 500	
N	100	100	
Non-participants			
Mean	204 574.60	9 641.87	**194 932.73**
Std. Deviation	98 681.56	5 806.76	
Minimum	40 150	2 280	
Maximum	481 800	43 225	
N	100	100	
Total (pooled)			
Minimum	35 040	2 100	
Maximum	537 280	64 500	
N	200	200	

Source: Survey Data (2022)

The price of milk per litre during the year 2019 was used to calculate the total revenues against the costs that a farmer had incurred over the year. Nevertheless, the relatively lower price offered by the Kikima Dairy Plant of Kshs 32 per litre of milk as compared to non-participants average price of Kshs 53.74 per litre of milk, coupled with a significantly high variable cost attached inputs such as mineral supplements and fodder was found to have significantly contributed to the lower revenues realized by the participants, despite the participants realizing a higher annual milk productivity per cow compared to the non-participants.

The distribution on the average total variable costs per annum among the participants and non-participants of milk processing is as show on figure 4.3;

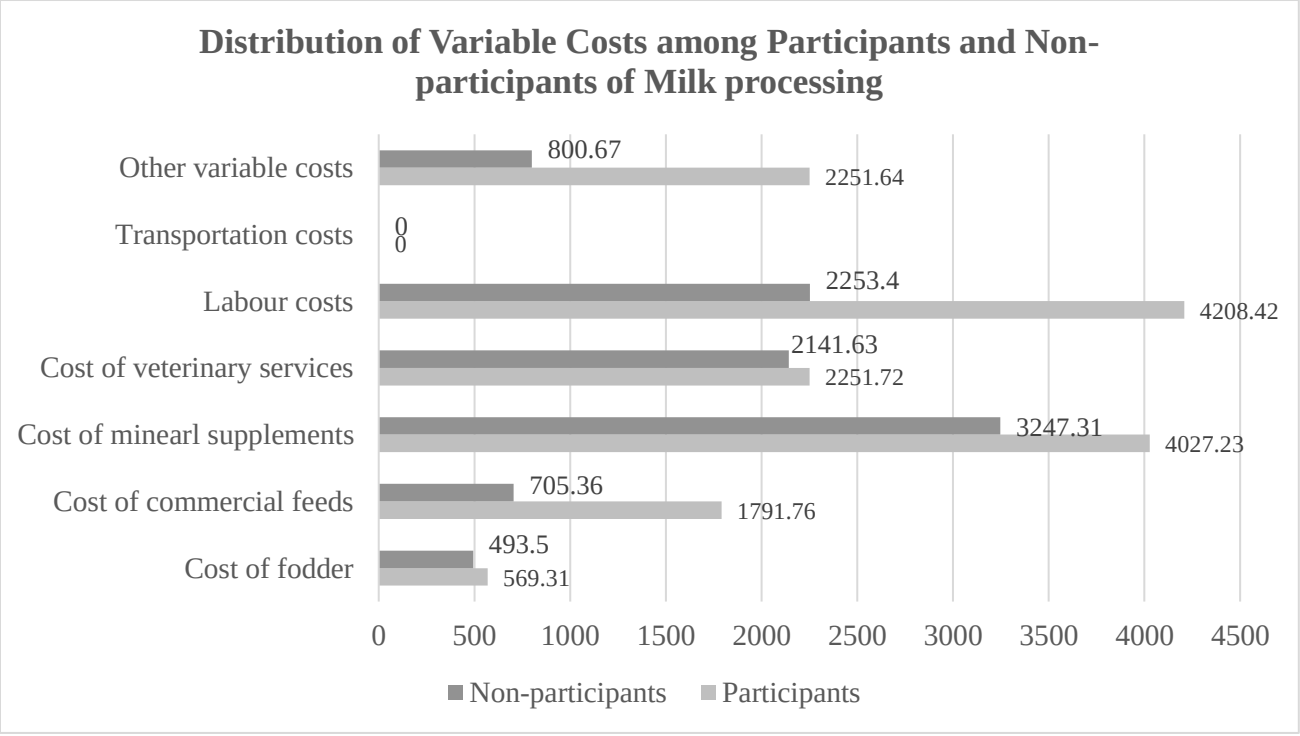

Figure 4.3: Average Total Variable Costs per annum among Participants and Non-participants of Milk processing in Mbooni and Kilome Sub-counties on Makueni County

Source: Survey Data (2022)

The t-test of the difference of statistical means was used to determine the extent of the difference in the annual gross margin per cow between the participants and non-participants. The results show that there was a statistically significant difference between the gross profit realized by the two groups (treated and control) at 1 percent (Table 4.3). This finding is consistent with that of Mutuku *et al.,* (2019); Mugula and Mishili (2018), who reported the existence of a significant difference in profitability between participants and non-participants of different agribusiness projects.

Table 4.3: T-test for difference in annual gross margin per cow between participants and non-participants of milk processing

Category	***Mean***	***Standard Error***	***N***	***Mean difference***	***T - Value***
Participants (treated)	121 127. 62	80 82.48	100	-73 805.11	5.88***
Non-participants (control)	194 932.73	98 68.15	100		

*, **, *** denote significance at 10 percent, 5 percent and 1 percent respectively

Source: Survey Data (2022)

With regard to the challenges that participants face in selling their milk to the dairy plant, 97 percent complained about having experienced delayed payment for their proceeds after supplying their milk to the dairy plant. While 86 percent of the participants, were unhappy with the low prices offered at the plant relative to other channels.

Relating to the benefits of participating in milk processing, 79 percent and 30 percent of the participants reported having their access to extension services and information improved

respectively. This could possibly explain the higher annual milk productivity among the participants. Pertaining to the main determinant of market choice among the farmers, 75 percent and 25 percent of the participants stated guarantee of payment and guarantee of market respectively. This could be the reason why some farmers still prefer selling their milk to the dairy plant even though it offers a lower price per litre of milk as compared to other channels available in Mbooni sub-county.

Eighty-four percent, thirteen percent and three percent of the non-participants stated their key determinants of market choice as being, the price offered, cash needs (urgency) and guarantee of payment respectively. While the participants stated their key determinants of market choice as being, guaranteed of a ready market throughout the year. The high preference for marketing channels offering higher prices could explain why the profit realized by non-participants was high, even though they faced a high risk of non-payment from the channels they supplied to.

4.3 Factors determining participation in milk processing

Table 4.4 shows results from the binary probit regression model on the determinants of participation in milk processing. After conducting the Variance Inflation Factor test, there was no evidence of multicollinearity as presented on Appendix 2. The VIF values ranged between 1.07-1.46, with the mean VIF being 1.29.

The results indicate that sex, education level and farming as the primary occupation of the household head negatively and significantly influenced the household's decision to participate in

Table 4.4: Factors determining farmers' participation in milk processing in Mbooni and Kilome sub-counties

Variables	*Pooled sample (n=200)*			
	Coefficient	*Std. Error*	*z- value*	*Marginal Effect*
Sex of the HH head (1= Male, 0= Female)	-0.235***	0.062	3.61	0.00
HH head education (Years of schooling)	-0.037***	0.009	3.70	-0.01
HH head Age (Years)	0.016**	0.008	2.40	0.01
Farming as primary occupation (1=Farmer,0=otherwise)	-0.539**	0.217	2.58	-0.25
HH head experience (Years of dairy farming)	0.027*	0.015	1.7	0.01
Household size	-0.022	0.048	0.44	- 0.03
Farm size (Hectares)	0.113	0.117	0.94	0.09
Access to credit services (1= Yes, 0= No)	-0.201	0.209	0.96	-0.06
Distance from the farm to the road (Km)	0.203	0.152	1..36	0.12
Access to extension services	0.007	0.044	0.20	0.04
Membership to a farmer group (1= Yes, 0= No)	0.243	0.370	0.75	0.16
Constant	-1.472	0.809	-1.69	
Prob > Chi2	0.0038			
Log likelihood	-123.76			
Pseudo-R^2	0.2928			

*, **, *** denote significance at 10 percent, 5 percent and 1 percent respectively

Source: Survey Data (2022)

milk processing. While age of the household head and years of experience in dairy farming positively and significantly influenced participation in milk processing.

Sex of the household head negatively and significantly influenced the household's decision to participate at 1 percent. This means male-headed households are less likely to participate in milk processing than female-headed households. This could be attributed to the fact that female farmers were more actively involved in the activities of the dairy enterprise for instance; feeding cows and milking, and thus are likely to participate in projects that relate to dairy farming as opposed to the male farmers. This is consistent with the findings by Mutuku *et al.,* (2019), who reported that male-headed households were less likely to take part in agribusiness projects.

Education level of household head negatively and significantly influenced participation at 1 percent. The marginal effects show that an increase in the years of formal schooling by one year, decreases the likelihood of a dairy farmer participating in milk processing by 1 percent. This implies that farmers with a higher education level are less likely to participate in milk processing. It is likely that farmers who are educated have access to more information pertaining to more profitable alternative marketing channels available within their locality and thus prefer not to participate in milk processing which offered a rather lower price per of litre milk. Farmers with a higher level of education can easily obtain, analyze and use information on new agribusiness projects and decide whether to participate or not (Namara et al., 2013). This finding is contrary to that of Muricho (2017) who reported high participation in agricultural commercialization projects among farmers with a higher level of education.

The age of the household head positively and significantly influenced participation at 5 percent. The marginal effects indicate that an increase in the age of the household head by one year,

increases the likelihood of a dairy farmer participating in milk processing by 1 percent. This implies that farmers of older age were more likely to participate in milk processing as compared to farmers of young age. This maybe be due to the fact that older farmers are likely to be more experienced with a higher probability of having the necessary resources hence being less risk-averse as compared to young farmers who might lack the necessary resources (for instance capital), hence being more risk-averse. The young farmers could have been risk-averse due to the high risk of delayed payment reported among farmers who sold their milk to the dairy plant. This finding is similar to that of Pattanayak et al., (2003) who reported high participation by farmers of older age in agricultural projects which provided alternative channels of marketing farm produce.

Farming as the main occupation of the household head negatively and significantly influenced participation at 5 percent level of significance. The marginal effects indicate given that a dairy farmer's main occupation is farming, their likelihood of participating in milk processing decreases by 25 percent. This implies that farmers whose main occupation and source of income was farming, were less likely to participate in milk processing. This means farmers who had off-farm income were more likely to participate. This may be due to the fact that farmers without off-farm income tend to prefer marketing channels that offer higher prices, so as to enhance their income. Also, they prefer marketing channels that offer instant cash which enables them to cater for their daily needs. This finding is consistent with that of Nwabuogo *et al.*, (2019) who reported that farmers who had other sources of income other than farming were more likely to participate in the roll-out of new agricultural technologies and in particular, the use of returnable plastic crates to reduce food loss along the tomato value chain in Nigeria.

The years of experience in dairy farming by the household head positively and significantly influenced farmers' decision to participate at 10 percent level of significance. The marginal effects indicate that an increase in the dairy farming experience of a farmer by one year, increases the likelihood of the farmer participating in milk processing by 1 percent. This implies that farmers with a higher level of experience in dairy farming were more likely to participate than farmers who had fewer years of experience. This finding is consistent with that of Davis et al., (2012) who reported high participation in new agricultural marketing channels among farmers with a higher level of experience in farming.

4.4 Effect of participation in milk processing on milk income

Table 4.5 shows results from the endogenous switching regression model which was estimated using the full information maximum likelihood estimation (FIML) method. All the coefficients presented in Table 4.5 are interpreted as normal probit coefficients.

From the results presented in Table 4.5, the Wald test was found to be highly significant, indicating the good fitting of the data in the endogenous switching regression model. This means there was an endogeneity problem that was controlled for, hence justifying the use of endogenous switching regression model in the analysis. The Wald test of independence of the selection equation and outcome equation was significant at 1 percent. This means that the null hypothesis of no correlation between participation in milk processing and milk income is rejected. This means that the independent variables in the outcome equation together explain the variation in milk income, which is the outcome variable.

Table 4.5: Endogenous switching regression model results for gross profit (milk income)from the dairy enterprise

Variables	*Selection equation (Pooled sample)*		*(Participants)*		*(Non-Participants)*	
	Coef.	*z- value*	*Coef.*	*z- value*	*Coef.*	*z- value*
Sex of the HH head (1= Male, 0=Female)	-0.65	0.26	2757.49	0.26	4312.61	0.22
HH head education (Years of schooling)	-0.01	0.58	5269.19**	2.24	6228.33	1.30
Farming as primary occupation (1=Farmer,0=otherwise)	0.54***	2.64	9842.45	0.51	12308.10	0.48
HH head experience (Years of dairy farming)	0.05*	1.70	-1156.94	1.00	-3649.04*	1.94
Household size (members)	-0.09	1.47	-5429.21	-1.45	3962.04	0.77
Farm size (Hectares)	0.12	1.27	0.18	1.08	17022.52	1.24
Access to credit services (1= Yes, 0= No)	-0.06	0.17	51130.72***	3.15	15336.51	0.72
Distance from the farm to the road (Km)	0.19	1..49	382.73	0.03	11999.40	0.66
Access to extension services	0.03	0.12	5701.28**	2.01	15627.83***	3.02
Membership to a farmer group (1= Yes, 0= No)	0.40	0.99	-4397.23	0.13	-1775.37	0.05
HH head Age (Years)	0.06***	2.64				
Breeding method used (1= AI, 0= Otherwise)			-4628.63	0.13	-2488.07	0.06
Cost of fodder (Kshs)			-8.77*	1.72	1.74	0.40
Cost of veterinary services (Kshs)			4.90	0.56	1.88	0.18
Cost of mineral supplements (Kshs)			-3.05	1.38	8.95***	2.16
Cost of labour (Kshs)			-0.99	0.53	2.73	1.44
Constant	-0.64	0.887	149194.3	6.23	147636.41	2.93
/lns1	11.57	1516.34				
/lns2	11.15	222.76				
Sigma_1	104779.51					
Sigma_2	69637.07					
rho_1	-0.83***					
rho_2	-0.10					
Loglikelihood	-2650.57					
Wald test χ^2 (17)	45.54***					
χ 2 statistics for overidentification				0.72 [0.43]		
LR test of independence equations χ^2 (1) 13.71 ***						

*, **, *** denote significance at 10 percent, 5 percent and 1 percent respectively

Note: p value in square brackets, denote residuals from the first-stage regressions for age

Source: Survey Data (2022)

The results presented in Table 4.5 indicate that the likelihood ratio test for joint independence of the three equations was statistically significant. This implies that the three equations are dependent of each other. The covariance terms rho_1 and rho_2 as shown in Table 4.5 are both negative but are significant only for the correlation between the participation choice equation and the milk processing participants' income equation. Since rho_1 is negative and significantly different from zero, this implies that there was self-selection in milk processing participation decision. This means that participation in milk processing may not have had the same effect on the non-participants if they chose to participate in milk processing (Abdulai & Huffman, 2014)

The negative sign implies the presence of a positive bias, giving an indication that farmers with above average gross profit had a higher probability of participating in milk processing. This is similar and consistent with the findings by Barrett & Croft, (2012).

The covariance term for the non-participants (rho_2) was statistically insignificant. This implies that in the absence of milk processing, there would be no significant difference in the average annual milk income realized by the project participants and non-participants caused by unobserved factors (Lokshin & Sajaia, 2004). The identification of the model requires that at least one variable in the selection equation would not appear in the outcome equation. In this study age of the household head was used as the identifying instrument. Age was expected to influence participation decision but not directly affect milk income (gross profit from the dairy enterprise). The age residual estimates were not statistically significant, this implied that the coefficients of the age variable had been consistently estimated (Wooldridge 2015).

To further check for the presence of multicollinearity among the independent variables in the endogenous switching regression model, the Variance Inflation Factor (VIF) was estimated. The rule is, if the VIF is greater than 5, that is an indication of multicollinearity among the exogenous variables (Green, 2003). The VIF test values ranged between 1.09 - 1.50 with the mean VIF being 1.29. This was an indication that there was no evidence of multicollinearity as presented on Appendix 3. To further rule out the presence of multicollinearity among the independent variables in the endogenous switching regression model, a partial correlation test was carried out. The results of the partial correlation test for multicollinearity revealed the absence of serious correlation as the correlation magnitude for all variables was found to be below 0.5 as presented in Appendix 4.

To test for heteroscedasticity, the Breusch-Pagan/Cook-Weisberg test was applied with the null hypothesis being that there was no heteroscedasticity (constant variance) among the error terms. The Chi-square was 0.40 with one degree of freedom and was found to be insignificant at a *p*-value of 0.53. This implied that there was no heteroscedasticity. Thus, the null hypothesis of constant error variance was not rejected. The results indicate that the positive and significant factors influencing the level of annual gross profit from the dairy enterprise among the project participants are level of education of the household head, credit access and access to extension services. For the non-participants, access to extension services and the cost of mineral supplements had a positive and significant effect on the level of annual gross profit from the dairy enterprise realized by the farmers.

The positive relationship between education level for participants and the level of muilk income could be due to the fact that farmers with a higher level of education can comprehend and apply efficient methods of production hence maximizing on their profitability (Olayiwola, 2019). The positive relationship between age and milk income is likely due to the fact that older farmers were more experienced in dairy farming and were well aware of the efficient and relevant dairy enterprise management practices as well as having gathered information on profitable marketing channels over their years of dairy farming. This is similar to the findings by Olayiwola, (2019), where the age of the household head was found to positively influence the gross margin levels realized by farmers.

The positive relationship between access to extension services and the level of milk income for both participants and non-participants could be attributed to the fact that improved access to extension services was likely to improve on farmer's knowledge on management practices such as pasture management, feeding methods, parasite and disease management, breeding methods as well as hay making, which were likely to improve on the overall productivity per cow, which in turn would increase the gross margin realized. These results agree with the findings of Abdulai and Huffman (2014) who noted that access to extension services had a positive relationship with the productivity and farm income of rice farmers.

The positive relationship between the cost of mineral supplements and milk income may be attributed to the fact that mineral supplements play role in milk secretion, lowers the incidence of diseases and reproductive health problems hence farmers incur lesser input costs in managing

diseases (Kanburi Bidzakin et al., 2019). Therefore, it is likely that the participants had optimally utilized mineral supplements.

The positive relationship between credit access for the participants and level of milk income is in line with the expectation that access to credit enhances the ability of a farmer to procure necessary inputs such as mineral supplements, fodder, AI services and other veterinary services, pay for labour as well as being able to procure exotic breeds of cows, and this would increase the milk yield realized and subsequently increase the gross margin level. This is similar to the findings by Bidzakin *et al.,* (2019) who reported an improvement in yield by farmers who had accessed credit.

The negative and significant determinant of milk income among the participants was the cost of fodder only. While for the non-participants, only the level of experience in dairy farming had a negative and significant influence on the level of annual milk income realized by the farmers. The negative relationship between the cost of fodder and gross profit from the dairy enterprise implies that as the cost of fodder increases, the level of gross profit realized by a farmer is likely to decrease. This is in line with the theory that costs have an inverse relationship with gross margin. This is because, the cost of fodder is expected to increase total variable cost which is subtracted from the total revenue to give the gross margin (Samboko, 2011).

The inverse relationship between experience and milk income is in contrast to the expectation that a farmer having practiced dairy farming for a longer period of time, he/she would have gained hands-on knowledge and skills pertaining the efficient management practices. For instance, pasture

management, pest and disease management and breeding methods. However, the observed negative relationship may be attributed to possible inefficiencies in production and mostly due to lack of training on best management practices, particularly for the dairy enterprise. This result is contrary to the findings by Samboko (2011) and Wainaina (2014) who reported a positive relationship between farmers' farm experience and productivity levels.

4.4.1 Effect estimates

As shown in Table 4.6, the results indicate that there is a significant and negative correlation between participating in milk processing and the level of milk income (gross profit from the dairy enterprise) realized. The ATT and ATU are presented in Table 4.6. This implies that participation reduces farmers' gross profit and also had the potential to reduce the annual milk income realized by the non-participants if they had participated.

Table 4.6: Effect of participation in milk processing on farmers' gross profit from the dairy enterprise

Outcome variable	Adoption status	Predictions		Treatment Effect	T-Value
		Treated	Control		
Annual Milk Income per Cow	ATT	60 795.42	121 124.80	-60 329.38***	-8.19
	ATU	135 155.60	195 109.80	-59 954.20***	-10.87
	Heterogeneity Effect	-74 360.18	-73 985.00		

*, **, *** denote significance at 10 percent, 5 percent and 1 percent respectively

Source: Survey Data (2022)

The causal effect of milk processing for the treated group (participants) was about Kshs 60,329.38. This represents about 49.8 percent decrease in the milk income realized by the farmers who participated in milk processing. Thus, participating lowers the milk income of participants from Kshs 121,124.80 to Kshs 60,795.42. The causal effect for the non-participants (control group), if they had chosen to participate in milk processing was found to be Kshs 59,954.20. This represents about 30.7 percent decrease in the milk income that the non-participants would have realized. Thus, participating would lower the milk income realized by non-participants from Kshs 195,109.80 to Kshs 135,155.60.

The reported negative effect in this study is also consistent with that of Mwambi *et al.*, (2016), who reported that participation in new agribusiness projects was not sufficient to improve farm income of Avocado fruit farmers. This negative effect was attributed to inefficient implementation of farming arrangements to promote spillover effects on other household enterprises. This study, therefore, contributes to literature by showing that the effect of agro-processing as well as agribusiness projects is not always positive and can go either way, thus the effect can be positive or negative.

This finding is in contrast with the view that participation in agro-processing projects has the potential to significantly improve farm income and profits realized by smallholder farmers (Phong, 2012). The above finding is also in contrast with that of to that of Manda *et al.*, (2021), who found out that smallholder farmers' participation in both single and multiple–commodity markets was positively and significantly associated with income. This was attributed to the favorable and enabling policy environment created by the local government. The negative effect on milk income

as reported in this study is also in contrast with that of to that Mmbando (2014), who established market channel choice has positive effect on household welfare. Therefore, participation in wholesale market channels was found to have significant positive effect on welfare.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Summary

The productivity of the few established cash crops in Makueni County is affected by the low rainfall reliability, which in turn leads to drought and crop failure. Thus, the dairy sector is a crucial source of livelihood for the residents in Makueni County. The dairy sector, however, is constrained by the lack of adequate processing capacity which has the potential to enhance the shelf life and retail price of milk. It's for this reason that the Kikima dairy plant was established to provide a ready market for farmers' milk and enhance the processing capacity within Makueni County. However, there is scanty empirical evidence on the effect this dairy plant has had on farmers' welfare in terms of improving profitability of the dairy enterprise.

It's for this reason that the current study assessed the effect of participation in milk processing on milk income among smallholder farmers in Makueni County, using the case of Kikima Dairy Cooperative milk processing plant. The specific objectives were: to describe the socio-economic, farm and institutional characteristics of dairy farmers, assess the profitability of milk production among dairy farmers, evaluate determinants of participation in milk processing and evaluate the effect of participation in milk processing on milk income. The study used primary data with a sample size of 200 respondents drawn from Mbooni and Kilome sub-counties in Makueni County. The respondents were stratified by participation and farmers were randomly selected from the two sampling frames to give a sub-sample of 100 project participants and 100 non-participants. Data were then analyzed using descriptive and inferential statistics.

The results of the socioeconomic, farm level and institutional characteristics of the respondents indicate that participants were significantly different from the non-participants with respect to the breeding method used, price received per litre of milk, farming as the primary occupation of the household head, number of lactating cows owned per household, farm size, age of the household head, experience in dairy farming, total annual milk income and total annual variable costs incurred.

The participants on average had a relatively higher annual variable cost, higher utilization of artificial insemination as a breeding method, higher number of lactating cows, larger farm size, age and experience in dairy farming compared to the non-participants. The participants also realized a higher level of milk productivity per cow compared to the non-participants although the mean difference in the milk productivity per cow was not statistically significant. While the non-participants had on average a relatively higher milk price per litre of milk, a higher prevalence of off-farm income and a higher total annual milk income compared to the participants.

The milk production profitability analysis results indicated that there was a significant difference in the gross margin realized by the two groups. Where, the non-participants were found to have a higher annual gross margin per cow compared to the participants. This could be attributed to the fact that the participants received a lower price per litre of milk (Kshs 32) compared to the non-participants who on average received Kshs 53.74 per litre of their milk. Also, the participants on average were found to incur a higher total variable cost of Kshs 15,100.08 compared to the non-participants who on average incurred a total variable cost of Kshs 9,641.76.

Relating to factors influencing farmer participation in milk processing, the factors which positively and significantly influenced participation in the project were the age of the household head and experience of the household head in dairy farming. However, sex, education and farming as the primary occupation were found to negatively and significantly influence participation. The insignificant variables included household size, farm size, credit access, distance to the road from the farm, access to extension services and group membership.

The endogenous switching regression model results indicated a negative effect of participating in milk processing on milk income. The results further indicate a significant difference between the average total milk income by participants and non-participants. With regard to factors influencing annual milk income; education level, access to extension, access to credit and cost incurred in purchasing mineral supplements were found to positively and significantly correlate with milk income. However, the cost of fodder and experience in dairy farming were found to negatively and significantly influence milk income.

5.2 Conclusions

The first hypothesis that there exists no significant difference in individual socio-economic, farm and institutional characteristics among participants and non-participants of milk processing was rejected. Therefore, this study concludes that participants and non-participants of milk processing were significantly different with respect to individual socio-economic, farm and institutional characteristics.

The second hypothesis that there exists no significant difference in the profit realized by participants and non-participants of milk processing was rejected. Therefore, this study concludes that participants and non-participants of milk processing were significantly different with respect to annual milk profits realized.

The third hypothesis that individual socio-economic, farm and institutional factors do not influence the decision to participate in milk processing was also rejected. Therefore, this study concludes that the decision by smallholder farmer to participate in milk processing is influenced by individual socio-economic, farm and institutional factors.

The fourth hypothesis that participation in milk processing has no effect on milk income was also rejected. Therefore, this study concludes that participation in milk processing has a negative effect on the milk income realized by smallholder dairy farmers in Mbooni and Kilome sub-counties.

Thus, this further study concludes that participating in milk processing is not a guarantee for realizing increased or higher gross profit among farmers in Mbooni and Kilome sub-counties. This could be attributed to the relatively lower price offered per litre of milk by the dairy plant which has a direct effect on the farmers' gross margin, as well as the higher production costs realized by participants which are likely to be as a result of the higher costs incurred in the purchase of fodder compared to the non-participants.

This study further concludes that smallholder farmers in Mbooni and Kilome sub-counties of Makueni County choose to participate in milk processing because of other motives, gains or factors and not necessarily financial gains. This is because the participants of milk processing sold their milk to the plant at a lower price despite having access to other channels offering better prices. This is attributable to the participants being risk-averse and therefore they preferred selling to the dairy plant where they were guaranteed of being paid as opposed to selling to middlemen in the informal sector who might default on payment. The participants were also risk-averse in that they avoided selling to the informal market where demand is not guaranteed as demand in the informal sector keeps on fluctuating. For instance, when schools close, farmers who normally sell their milk to schools have to look for another market.

5.3 Policy recommendations

Based on the finding that the milk price offered at the plant was a key determinant of profits and milk income realized by farmers, this study recommends that the plant management should consider offering a quality-based payments to farmers. This would potentially solve the problem of participants of milk processing getting low prices for their milk. This will boost their gross profit from the sale of milk and eventually the welfare of the participants would improve, as well as attract participation by other farmers. Notably, being paid on a flat rate per litre of milk leaves the processor to benefit more than the farmers from the by-products of milk.

Milk quality is important in dairy production since it affects milk processing, shelf life and overall profitability (Barbano & Santos, 2006). Improved raw milk quality been linked to improved incomes for farmers, lower milk rejection, better processed product quality, lower processing

costs. The aspect of Quality Based Milk Payment gives smallholder farmers an opportunity to earn more for producing milk that meets certain set standards. Under the system, farmers who produce milk that meets the set standards earn bonuses on top of the normal milk prices. Some of the Parameters used are total plate count, presence of antibiotics residues, adulteration, total solids (including fat and protein) (Hibma, 2016).

Based on the low milk yield among non-participants, the study found out that better access to extension services and utilization of mineral supplements were among the key factors which contributed to having higher milk productivity among the participants. On this note, the county government of Makueni, development partners and private sector actors should consider improving on dairy farming extension services delivery targeting the non-participants of milk processing, especially on pasture management and good feeding methods which have the potential to enhance on milk productivity. For instance, feeding ration formulation and optimal utilization of mineral supplements.

In order to encourage attract more dairy farmers to participate in milk processing, this study recommends that the plant should introduce a structured trading system to the farmers. The structured trading system would entail a scenario whereby, once a farmer delivers his/her milk to the dairy plant, he/she is issued with a certified receipt in exchange for their milk. Farmers then can take the receipt as loan collateral at a pre-identified financial institution with which the dairy plant has had an agreement or arrangement. The farmer is then allowed to access credit depending on the value of their receipt. This would enhance the dairy farmers' capacity to buy necessary farm

inputs e.g.: mineral supplements, which enhance productivity and enable them to cater for their daily cash needs as they wait for final payment. The provision of loans using milk proceeds as collateral is likely to positively influence farmers' decision to participate in milk processing as well.

5.4 Limitations of the study and recommendations for further research

The current study considered only socio-economic, farm and institutional characteristics of a household as the only attributes influencing a farmers' decision to participate in milk processing. However, there are other attributes relating to the milk processing plant and its operations that are likely to influence participation, for instance; mode of payment of farmers' proceeds, frequency of payment, trust among farmers and the plant or parties involved, quality of milk acceptable by the plant.

In this study, gross profit from the sale of milk (milk income) was used as the only welfare indicator. However, farm income in Makueni county is generated from multiple sources due to high prevalence of income diversification. Therefore, this study did not take into consideration income generated from other farming enterprises in estimating the total annual farm income of a household. Moreover, the current study did not factor in the overall household income level and other dairy farming characteristics such as herd size, number of lactating animals, cost of food, etc. as factors that might influence participation into milk processing. Therefore, other studies could focus on evaluating the impact or effect of the same dairy plant on other welfare indicators,

for instance; effect on housing, education, cost of living, life expectancy, happiness levels, occupation satisfaction, poverty, food and nutrition security.

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APPENDICES

Appendix I: Household survey questionnaire

Section A: Introduction

A team of researchers from the **Department of Agricultural Economics, University of Nairobi, invites you to take part in this (approximately 15-minute) survey to share your experiences in dairy farming.** The reason for undertaking this study is to gain insights and knowledge on the performance of the dairy sub-sector in Makueni County

The data generated from this process will be used strictly for academic and research purposes and may help inform policies around the possible areas of improvement to enhance on farmer welfare in Kenya. **Your responses are strictly confidential**.

Thank you for your interest in our survey. Your participation is voluntary and highly appreciated.

Section B:

Questionnaire Number …….

Date ……..

Enumerator's name …….

1.0 General information

1.1 County of Residence
1.2 Sub-county ……..
1.5 Phone number……..

Instruction: please circle the correct response

2.0	**Household characteristics**	**Coding**
2.1	Family position of the respondent	1= Household head 2= spouse of the household head 3= Grownup child (18 years & above) 4= Relative 5= other (specify)
2.2	Sex of the household head	1= Male, 0= Female
2.3	Marital status of the household head	1. single 2. Married 3. Separated 4. widow/widower
2.4	Age in years of the household head	

2.5	Education level of the household head	1= Primary 2= Secondary 3= College 4= University 5= No formal education
2.6	Experience in dairy farming (number of years)	
2.7	What is the household's head primary occupation?	1= Self-employed - Farming 2= Salaried employee/formal employment 3= casual laborer/informal employment 3= Business person - self employed
2.8	How many are you in your household?	

3.0 Farm characteristics and productivity

3.1 How many dairy cows (lactating) does your household own?

3.2 What breed are your lactating dairy cows?

1= Exotic (Friesian, Guernsey, Ayrshire, Jersey), 2= local (Sahiwal, boran, zebu), 3= cross breed

3.3 How much land does your household own in hectares?

3.4 How much land do you use for growing fodder for your own use in hectares (do not consider the area of land under fodder for sale or area of land under fodder not meant for feeding your cows)?

3.5 What is the tenure system of the land used for growing fodder/grazing?

1. =owned with title, 2= Owned without tittle, 3.= Rented in 4.=Rented out 5=communal/public

3.6 which feeding system do you use?

1. Free range grazing 2. tethered grazing 3. Stall feeding (zero-grazing)

3.7 Does your household have any other enterprise apart from dairy farming? 1.Yes, 2. No

3.8 If yes which ones? 1. Maize farm 2. Pig farm 3. Shop 4. Poultry 5. Vegetable farm 6. Fruit farm 6. Others (specify)

4.0 Market access information

4.1What is the distance to the nearest main market centre from the farm? (Kms)

4.2 What is the distance from the farm to the road? (Kms)

4.3 What is the type of the road from the farm to the nearest main market centre? (Kms)

(Codes: 1=Tarmac, 2=All-weather marram road, 3= seasonal marram road, 4=others(specify)

4.4	Did you buy any milk for home consumption in the year 2019?	1=yes 2=No
4.5	What kind of storage do you use in transporting your milk to your market?	1= Plastic container 2= standardized milk charm 3= Others (Specify)
4.6	Where do you sell your milk	1= Kikima dairy plant _____ 0= Others _____
4.7	What benefits have you received from selling to Kikima Dairy Plant?	1= Loans/Credit 2= Extension services 3= Market information/advice 4= Others (Specify)
4.8	What are the shortcomings of selling to Kikima dairy plant	1= Delayed payment 2= Non payment 3= Poor leadership at the plant (eg: corruption) 4= Low payment rates (price offered) 5= Others (Specify)
4.9	What are the marketing options available in your area	1= Selling directly at the market centres 2= Selling at your farm gate 3= Selling through brokers 4= Others (Specify)
4.10	What is the main determinant of your decision on which market to sell to?	1= Price offered, 2= Cash needs (urgency), 3= Mode of payment, 4= Guarantee of payment 5= Guarantee of a ready market 6= Lump-sum payment 7= Others (Specify)

5.0 Farm profitability

5.1 Have you been milking your cows in 2019? 1=Yes; No=0

If yes, please enter the following information for all the cows milked in the year 2019.

5.2 Number of Lactating cows _____(record up to a maximum of 10 cows)

I would like to know about the cost of your farming operations incurred in the year 2019. Provide records if you have any (NB: Enumerator to assist the farmer in calculating).

Table 1: Gross margin for dairy in 2019

Cow numbering	**1**	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Average milk output per day (morning and evening milk) (Litres)										
Which breeding method did you use on your cows in 2019? (1=Artificial insemination, 2= bull, 3=both)										
Price of milk (Kshs/Litre)										
Out of your total milk output how much was consumed (including any given as a gift to friends) at home per day in 2019? (Litres)										
Total revenue (Kshs)										
Total costs (Kshs) Cost of fodder per month										
Cost of commercial feeds per month										
Cost of veterinary services per month including artificial insemination if any										
Cost of mineral supplements per month										
Cost of water per month										
Labour costs per month (wages and casual labourers)										
Transportation costs per month										
Other variable costs per month										
Total costs (Kshs)										
Gross margin (TR – TC) (Kshs per week)										

6.0	**Institutional factors**	
6.1	Did you ever require credit for your dairy enterprise in 2019? If yes, did you access the credit?	1= Yes; 2= No 1= Yes; 2= No

6.2	If yes, what was your source of credit?	1= Tetheka fund 2= Uwezo fund 2= Cooperatives 3= Microfinance 4= Bank 5= Family/ Neighbour/friends
6.3	If No, what were the problems in getting credit?	1= There is no credit service around here 2= High interest rates 3= They need collateral for loan
6.4	Are you a member of any group association? If yes, what kind of association?	1=yes 2=No 1=women group 2= men group 3= livestock group 4= water use group
6.5	Are you a member of any farmer organization/group? For how long have you been a member? Do you pay a membership subscription fee? Do you participate in decision making in your group?	1= Yes, 2= No 1= Yes, 2= No 1= Yes, 2= No
6.6 6.7	Did you receive any dairy related extension service in 2019? If yes, what was the source of the extension service? What was the frequency of the extension service (How many times were you visited by an extension service provider)? Did you receive any training in the following in 2019? (tick all that apply)	1=Yes, 2=No 1=Government, 2=Private (NGO, CBO, other farmers) 1=weekly, 2=monthly 3=quarterly, 4=annually 1. Livestock breeding 2. Veterinary services 3. Parasite and disease management 4. Pasture management 5. Hay making 6. none
6.8	Has selling to Kikima dairy plant improved your access to credit?	1= Yes 2= No
6.9	Has selling to Kikima dairy plant improved your access to extension services?	1= Yes 2= No
6.10	Has selling to Kikima dairy plant improved your access to farm inputs?	1= Yes 2= No

Thank you for your time and patience.

Appendix 2: VIF for the probit model

Variable	VIF	1/VIF
Experience in dairy farming	1.46	0.685234
Education of household head	1.46	0.685672
Farm size	1.41	0.707330
Age of household head	1.35	0.742768
Sex household head	1.34	0.748364
Farming as the primary occupation of household head	1.29	0.773344
Distance from the farm to the main road	1.29	0.776232
Household size	1.22	0.822475
Membership to group	1.20	0.832035
Access to extension services	1.15	0.866496
Access to credit	1.07	0.931601
Mean VIF	1.29	

Appendix 3: VIF for the Endogenous Switching Regression model

Variable	**VIF**	**1/VIF**
Experience in dairy farming	1.50	0.666791
Farming as the primary occupation of household head	1.50	0.668079
Education of household head	1.49	0.670304
Cost of labour	1.45	0.689311
Age of household head	1.40	0.714115
Sex household head	1.37	0.731769
Distance from the farm to the main road	1.36	0.737513
Farm size	1.30	0.769739
Household size	1.24	0.804874
Membership to group	1.22	0.819044
Breeding method	1.21	0.825515
Cost of mineral supplements	1.18	0.847244
Cost of Fodder	1.17	0.856986
Cost of veterinary services	1.12	0.894991
Access to credit	1.10	0.906073
Access to extension services	1.09	0.915085
Mean VIF	1.29	

Appendix 4: Partial and Semi-partial correlations for income (dependent variable) with independent variables as used in the Endogenous Switching Regression

Variable	Partial Correlation	Semi-partial Correlation	Partial Corr.^2	Semi-partial Corr.^2	Significance Value
Education of household head	0.1467	0.1268	0.0215	0.0161	0.0482
Age of household head	0.0117	0.0100	0.0001	0.0001	0.8754
Farming as the primary occupation of HH head	0.0685	0.0587	0.0047	0.0034	0.3585
Experience in dairy farming	-0.1994	-0.1740	0.0397	0.0303	0.0070
Household size	-0.1120	-0.0964	0.0125	0.0093	0.1324
Farm size	0.1485	0.1285	0.0221	0.0165	0.0454
Sex of household head	0.0093	0.0080	0.0001	0.0001	0.9008
Access to credit	-0.1574	-0.1363	0.0248	0.0186	0.0339
Distance from the farm to the main road	-0.2065	-0.1805	0.0426	0.0326	0.0052
Access to extension service	-0.1283	-0.1107	0.0165	0.0123	0.0843
Membership to group	0.1764	0.1533	0.0311	0.0235	0.0172
Breeding method	0.0204	0.0175	0.0004	0.0003	0.7842
Cost of Fodder	-0.1280	-0.1104	0.0164	0.0122	0.0851
Cost of veterinary services	0.0479	0.0410	0.0023	0.0017	0.5205
Cost of mineral supplements	-0.1499	-0.1297	0.0225	0.0168	0.0434
Cost of labour	0.0216	0.0184	0.0005	0.0003	0.7727