EVALUATION OF FACTORS INFLUENCING SMALLHOLDER DAIRY FARMERS' DECISION TO DELIVER MILK TO COOLING PLANTS IN SOTIK SUB-COUNTY, KENYA

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A Thesis Submitted to the Graduate School in partial fulfillment for the requirements of the Master of Science Degree in Agricultural Economics of Egerton University

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DECLARATION AND APPROVAL

I declare that this thesis is wholly my original work and to the best of my knowledge has not been presented for the award of any degree in this or any other university.

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DEDICATION

I dedicate this work to my parents Mr. Daniel Langat and Mrs. Elizabeth Langat for their sincere love and commitment towards my studies. Special thanks also go to my beloved brothers; Wilson, Geoffrey, David, Charles, Bernard and Vincent, My Sisters; Beatrica and Janeth not forgetting Mr. Richard Koske for all the support. It was a sacrifice on their part but I hope the quality of their lives will improve in the years to come.

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ABSTRACT

Kenyan dairy sub-sector has been undergoing many changes since the collapse of Kenya Cooperative Creameries (KCC) in 1992. There have been developments in establishment of milk cooling plants which are thought to reduce milk losses and benefit the smallholder dairy farmers besides bulking milk at one point for the processing firms. However, there is evidence of underutilization of the cooling plants and the reasons that inform farmers' decision to use the cooling plants as milk marketing outlet have not been clearly established. Hence, there seems to be reluctance by farmers to deliver their raw milk through the cooling plants. To bridge this gap, the current study sought to evaluate factors influencing smallholder dairy farmer's decision to deliver milk to cooling plants in Sotik Sub-County. Multi-stage sampling procedure was employed to select 150 smallholder farmers. Data was collected using structured questionnaires administered by enumerators and analyzed using both descriptive and inferential statistical techniques. Multivariate probit results indicated that; age, gender, education level, household size, price, distance, access to credit, extension service and group membership significantly influence the choice decision of the farmer to deliver milk to cooling plants. Farmers delivering to cooling plants had higher gross margin of KES 10.84 per litre compared to KES 8.15 and KES 7.27 per litre for cooperatives and vendors/neighbors, respectively. The observed difference was due to the costs incurred in selling milk to the different marketing outlets. It was also found that delivering milk to cooling plants positively and significantly increases the income of dairy farmers by KES 16,680 more than their counterparts per lactation period. This is an indication that a cooling plant is economically viable and an important tool in increasing smallholder dairy farmer's income. The study therefore, recommended policy interventions in increasing market awareness through creation of strategies that would improve socio-economic conditions of smallholder. Furthermore, the government and non-governmental organizations in the dairy sector ought to expand the modern channels by establishing more milk cooling centers since they are more rewarding to the farmers.

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LIST OF ABBREVIATIONS

CBS- Central Bureau of Statistics

FAO- Food and Agriculture Organization

GDP- Gross Domestic Product

GMA- Gross Margin Analysis

GoK- Government of Kenya

IEBC- Independent Electoral and Boundaries Commission

ILO - International Livestock Organization

ILRI- International Livestock Research Institute

KCC - Kenya Cooperative Creameries

KDB - Kenya Dairy Board

KNBS - Kenya National Bureau of Statistics

MVP- Multivariate Probit

MoLD- Ministry of Livestock &Development

NGO`s - Non-Governmental Organizations

RUM - Random Utility Model

SDP- Smallholder Dairy Project

PSM- Propensity Score Matching

CHAPTER ONE

INTRODUCTION

1.1 Background information

Milk production is one of the most important investment enterprises in the world where small scale farmers earn a regular income, employment and contributing to the household food security on a daily basis throughout the year (Omore *et al*., 2004). In Africa, Kenya is the only country, after South Africa that produces sufficient milk for both domestic consumption and export. It is the single largest agricultural sub sector larger than even tea and is estimated to contribute about 14 percent of the agricultural GDP and approximately 4.5 percent of the national GDP (Mutua-Kiio and Muriuki, 2013; FAO, 2014). The milk production trend has been increasing in Kenya due to an increase in demand for milk and its products. It is currently approximated that 4.2 billion litres is produced per day with smallholder farmers accounting for over 70 percent of the total production (MoLD, 2010). The sub sector is also providing a means of livelihood to more than 2 million Kenyan households and employs more than 600,000 smallholder dairy farmers (Muriuki *et al.*, 2007; Techno Serve, 2008).

Before liberalization of the Kenyan dairy industry, the main challenges were mainly addressed through the Kenya Cooperative Creameries (KCC). This was a farmer’s private organization that received high profile and heavily depended on government support (Staal *et al*., 2008). With the liberalization of the dairy sector in 1992, new institutional and economic arrangements in the dairy sector that include milk collection, processing and marketing outlets emerged (Karanja, 2003). However, only a few of the smallholder dairy farmers, community based organizations and cooperatives expanded their enterprises to include establishment of other milk marketing outlets (Mburu *et al*., 2009). Smallholder dairy farmers could therefore enhance their growth and profitability by being involved in production and marketing activities by delivering their milk to these outlets.

Marketing of milk to final consumers in Kenya is undertaken through formal and informal channels. The formal channel is made of licensed operators who include more than 25 processors, 59 mini dairies, 68 cottage industries and 1172 milk bars (KDB, 2014). Important players in informal marketing system include: neighbors, local shops, restaurants, hotels and milk vendors or middlemen. The informal markets are unstable and are exploitative, particularly during the glut production season. Prices are determined arbitrarily, and under-pricing is common during this season (Omore *et al.*, 2004). Farmers may also sell milk to more than one outlet perhaps for different purposes.

Since most of the small scale dairy farmers live in remote areas characterized by poor roads and lack of electricity, their major concern in selling milk is the development of the best marketing outlet that minimizes losses and maximizes their profits. There has been great emphasis on the organization of smallholder milk producers into groups such as self-help group, cooperatives, and companies in order to enhance efficiency in marketing of raw milk through bulking and cooling. However, there is an apprehension by smallholder dairy producers on whether to take advantage of the emerging opportunities of these modern marketing outlets (Wambugu *et al.*, 2009). One of the important conditions for the dairy farmers to reap their economic benefits from the dairy sector is the establishment of assured marketing outlets which are sufficient and remunerative to them (Omore *et al*., 2004). However, there are limitations in harnessing these opportunities by smallholder producers to access the markets.

The government of Kenya through the Ministry of Agriculture with the support of other private sectors in the dairy sector has established milk cooling plants project which serves to help in collection of milk in places that were not easily accessible during the rainy seasons and also to capture the afternoon milk produced by the farmers which more often is not collected by the New KCC (MoLD, 2010). These cooling plants are left to the farmer organization and the community to own and run them. The project is thought to reduce the farmers' transaction costs as well as milk losses therefore, boosting the dairy industry by enhancing milk supply at competitive prices (Karanja, 2003; KDB, 2014). Notwithstanding the dominance of informal milk marketing outlets, cooling plant is seen as an important and more income generating marketing outlet for many rural smallholder dairy farmers (Wambugu *et al.*, 2009). However, the decision on where to sell milk has remained with the milk producer. This decision have a direct effect on the rest of the farmer`s marketing activities and once it is established, it is difficult to change particularly in the short run. Although this may be less true for smallholder farmers, what influence a farmer to deliver milk or not to a certain marketing outlet still remains to be a challenge.

1.2 Statement of the Problem

Dairy farming has been practiced in Kenya by many generations both for household consumption as well as generating income. There has been an increase in milk production which has necessitated the government and other private companies in the dairy sector to support the establishment of milk cooling plants. Their main aim is to catalyze the rural economic development, reduce milk losses and benefit the smallholder dairy farmers. Despite the support and high profile given to these cooling plants, many farmers are still reluctant to deliver their milk through them. Little information is known on whether the benefits accrued from cooling plants differ from those of other marketing outlets. This research therefore endeavors to address this gap based on factors influencing farmers' decision to deliver milk to cooling plant. Identifying these factors is crucial in terms of pinpointing the possible areas of interventions that may lead to capacity utilization of the cooling plants and also helping dairy farmers to maximize benefits out of their dairy production.

1.3 Objectives

1.3.1 General objective

To contribute to increased investment in the dairy sector and improvement of the livelihood of smallholder dairy farmers through implementation of viable milk marketing outlets in Sotik Sub-County.

1.3.2 Specific objectives

1. To determine socio-economic factors influencing smallholder dairy farmers' decision to deliver milk to cooling plant.
2. To determine the effect of delivering milk to cooling plants on gross margins.
3. To determine the effect of delivering milk to cooling plants on smallholder dairy farmer's household income.

1.4 Research questions

1. What socio-economic factors influence the farmers' decision to deliver milk to cooling plant?
2. What are the effects of delivering milk to cooling plants on gross margins?
3. What is the effect of delivering milk to cooling plants on smallholder dairy farmer's household income?

1.5 Justification

Dairy sector in Kenya is incorporated as one of the developments in the vision 2030, aimed at fighting food insecurity in the country. In Sotik Sub-County, dairy farming is the basis of livelihood for most smallholder farmers and almost each and every household has at least one dairy cow which they depend on for household consumption, as well as source of income. Additionally, income from cash crops especially tea in the Sub-County is not received regularly. These necessitate farmers to diversify their income source to include dairy farming. To ensure increased investment in the dairy sector, implementation of projects that include milk cooling plants is necessary to boost the welfare of small scale farmers. The findings of this study therefore may help in providing the necessary knowledge required for improving the dairy sector. Policy makers, NGOs and other stakeholders might also get valuable information on appropriate measures and design of the cooling plants that could benefit farmers through increased yields and reduction of milk losses. This eventually may lead to an increase in the living standards of the smallholder dairy farmers.

1.6 Scope and limitation of the study

This study was restricted only to smallholder dairy farmers in Sotik Sub-County who delivered their milk to existing marketing outlets. Information on socio-economic, institutional and marketing factors was collected by use of structured questionnaires. Due to lack of farm records among dairy farmers, the study mainly relied on the farmer's memory in the collection of the data.

1.7 Definition of terms

Smallholder dairy farmer: These are farmers keeping less than 10 dairy cows on less than 5 ha of land (Henk *et al.*, 2007). Therefore farmers with a herd of less than ten dairy cows irrespective of the breeds are considered to be smallholder farmers.

Milk cooling plant: A cooling plant is defined as a milk marketing outlet where milk is collected, handled, stored or chilled before taken to the main milk processors for final process.

Marketing outlet: This is a business structure of interdependent organizations that reach from the point of product origin to the consumer with the purpose of moving products to their final destination (Koler *et al*., 2003).

Socio-economic factors- Are factors that influence both the social and economic well-being of an individual.

CHAPTER TWO

LITERATURE REVIEW

2.1 Dairy industry in Kenya

Kenya is generally self-sufficient in milk production and other dairy products. Its annual milk production is estimated at about 2.5 billion litres and the domestic supply potential is about 4.2 billion litres (Muriuki *et al*., 2007). The production is dominated by small holder farmers producing about 95 percent of the milk and the large scale dairy producers accounting for about 5 percent per cent of national milk production (KDB, 2014).

Milk processing on the other hand is dominated by four major processors which include New KCC, Brookside Dairies, Githunguri Dairy Farmers Cooperative and Processors and Spink knit dairy cooperative (Mburu *et al.*, 2007). In 2010 alone, Brookside had a 40 percent share of the Kenyan dairy market, with milk sourced from approximately 120000 suppliers. Seven percent of these were commercial farmers and the rest were small scale producers (KDB, 2014). Most of the milk producers deliver their milk directly to these companies. This is not as a result of lack of investment in other delivery channels but rather because of their strong demand for the milk products and services that they offer to the milk stakeholders. In the contrary, investment in the dairy sector both in public and private sectors, has often failed leading to underutilized capacity of milk processing plants and other cooling facilities like the cooling plants (Omore *et al.*, 2004).

2.2 Milk marketing outlets

The Kenya's dairy marketing outlets can be referred to as channels that collects, process and move processed milk product to final consumers. They are categorized into three; direct sales by producers to neighbours which accounts for more than half of smallholder's marketed milk; rural-to-urban sales through informal traders who act as transporters and Rural-to-urban sales through Farmers' Collective Groups (Ngigi, 2004). Major processors have their own collection centers, cooling centers, bulking and transportation systems where stainless steel cans are used for bulking milk from individual suppliers and delivering it to processors' collection points. In some areas, powerful milk intermediaries (traders) acts as intermediaries between the market and the milk producers (Omore, 2007).

In Sotik Sub-County, three formal marketing outlets intermediaries that include New Kenya cooperative creameries (New KCC), Brookside Dairies and milk cooling plants owned by either processors or the farmer groups are distinguished. Additionally, there are traditional marketing outlets that exists namely; villagers, milk traders or vendors. The common feature among them is that they all purchase fresh milk from dairy producers.

2.3 Characteristics of processing companies and milk cooling plants

The main milk processing companies in Kenya are the New KCC, Brookside Dairies; Spin Knit Dairy Cooperative and Githunguri Dairy Farmers Cooperative Society. New KCC is a parastatal which according to the Livestock Policy in Kenya has the responsibility of collecting fresh milk from dairy producers especially those in rural areas far from dairy processing plants, processing fresh milk into standardized milk and milk products, and selling and distribution of high quality milk and milk products to consumers (Ngigi, 2004; Muriuki *et al.,* 2007).

Milk cooling plants on the other hand emerged in the dairy sector after liberalization in the milk sector to support the main processing companies especially by cooling the milk as it awaits processing (Wambugu *et al.*, 2011). Most of the farmers have joined hands together to form cooperatives while others establish their own cooling plants (Mburu *et al.,* 2009). Cooling plants are considered as indirect channel characterized by low levels of organization, no taxation or regulation; low wages with transactions are mainly conducted in cash, low productivity because of the reduced size of the market, limited access to credit by the farmers, and activities that complement the formal economy. Due to perishability nature of raw milk, cooling plant is seen as efficient means of reducing the milk spoilage. Additionally, milk is mainly produced by indigenous cattle which are widely distributed in different areas including remote villages with problems like poor road infrastructure and inadequate utility services (Msanga, 2009). These problems blend inefficiency in milk collection and increase the cost of collection and processing. Therefore, cooling plants serve as the best delivery system that can benefit the smallholder dairy farmers.

2.4 Factors influencing farmer's decision on which milk outlet to use

Choice for the milk marketing outlet is the farmers' decision on where to or not to sell their produces. The choice of marketing outlet is determine by numerous factors which include; socio-economic factors, institutional factors, market factors and external factors such as political stability of the nation, natural disaster and other calamities. These factors could have negative or positive effects, which could either improve or cause a decline in the welfare of the actors. Dairy farmers sell their milk to any outlet of their choice, including fellow farmers, local traders, and even buyers from other regions, or neighboring countries. This has widened the choices for a farmer and hence leading to the growth potential of market outlets that compete for the raw milk (Kumar *et al*., 2010). Competition by the processing companies enhances healthy and attractive markets therefore producers have to make a choice from the existing channels which can maximize their utility. The choice of milk outlet is a fundamental decision for the milk producer where a number of factors and objectives contribute to such decisions. Several studies have been carried out to identify the factors that influence the producer's choice of marketing channels.

Mburu *et al*. (2007) analyzed the determinants of smallholder dairy farmers' adoption of various milk marketing channels in Kenya highlands using a Logit model. In their study they found that, the total number of cows milked, average milk price and farm size negatively influenced farmers' adoption of milk marketing through the dairy cooperative channel. Farmers therefore opt for the cooperatives because of uncertainties of the other channels that existed. It then goes without saying that the higher the price offered by a delivery channels, the higher the chances of delivering to that particular channel (Arega, 2007; Jari, 2009). Sikawa and Mugisha (2010) on the other hand analyzed factors that influence south-western Uganda milk farmers' choice of the milk marketing channel in Uganda. In their study, they categorized milk market choices into a binary outcome of formal and informal market channels. The Heckman Probit model results indicated that membership to a cooperative, age of the dairy farmer, volume of milk produced, form of payment, level of education of the dairy farmer and marketing costs were significantly influencing the choice of milk marketing outlet.

Nyaupane *et al.* (2010) observed that farmer's choice of a marketing outlet is based on its convenience and economic profitability. In their study, it was found that farmers choose to sell to a channel that offers the highest profits. In their survey probit results, they concluded that demographic farm characteristics such as farm size, diversification and premarket characteristics had significant influences on the farmer`s marketing choice.

Institutional and technical factors also influence the choice of agricultural marketing among smallholder farmers (Tsourgiannis *et al.*, 2002). Tsourgiannis argued that transaction costs, market information flow and the institutional environment which encompasses formal or informal rules of an organization in the markets and the legal environment influences the choice decision of a farmer. In their results, they concluded that a rational farmer will first consider the costs involved in a channel and the benefits associated with that particular channel thus can choose a channel that offers high utility.

Jari *et al.* (2009) looked at educational level of the farmer as the determining factor of choice decision. Educational level positively influences the market choice and participation of that channel. This is attributed to the roles in which education plays. The roles of education may include enhancement of managerial competencies and successful implementation of improved marketing practices. The more the education level achieved by an individual, the higher the chances of choosing a more paying delivery channel due to knowledge exposure (Omore *et al.*, 2009). Education improves the readiness of the dairy household to accept new idea and innovations. It also helps in getting updated demand and supply price information which in turn enhances the willingness to produce more milk, and thus increasing the farmer's delivery channel participation level.

Working off farm is also seen to influence the decision of a farmer. The probability of smallholder farmers opting for dairy processing companies increased if the household head is working off farm (Omore *et al*., 2004). The farmers can get income which could cater for the daily expenses and therefore can patiently wait for the monthly income from dairy cooperatives. It is expected that off farm commitments like jobs may increase the chances of farmers opting for milk cooling plants or other traders since they save their time and at the same time can handle their milk supply on top of better payments.

Wambugu *et al.* (2011) in the study on dairy farmer's decisions found out several reasons why famers may switch to other milk agents in the marketing system. These reasons include; the special assessment that are being charged by cooperatives, prices paid after deductions, prices which are too low, excessive hauling costs, and inadequate provision of on-farm services. More Similar reasons were also identified to affect the Southern dairy farmers' degree of satisfaction with milk handlers (Omore *et al.*, 2004). Both studies concluded that prices received from the agents, assessments and deductions, market assurance, and hauling costs were identified to be affecting the degree of satisfaction and decision of the farmer.

Muriuki (2003) in his study alluded that herd size significantly affect farmer`s marketing channel choice. This is because of the fact that the herd size of dairy cattle determines the volumes of milk available for sale and therefore influences farmer`s choice of marketing channel. The large milk producers were believed to get price incentives because of high bargaining power of the group as well as lower transaction costs (Gong *et al.*, 2009). In addition, the number of animals kept by a farmer determines the total production costs. This therefore influences the amount of working capital that is needed on the farm and hence motivating those farmers with a large herd size to prefer delivering their milk to channels that handle big volumes and pay milk revenues in lump sum money like the KCC therefore living behind other channels (Anjani *et al.*, 2011).

2.5 Effects of milk marketing outlets on household income

Farmers' marketing channel choice decision is seen as one of the available income strategies, whereby a farmer will select a given channel if the utility obtained from it out-ways that of the alternatives. The decision to choose a particular marketing outlet is based on the maximization of a given utility function. A farmer selects the marketing outlet that maximizes his/her utility (McFadden, 1986). The farmer is likely to choose an outlet that gives a higher utility among the alternatives (Mburu *et al.*, 2007). According to Jari (2011), household income is determined by various socio-economic factors. For farm households, income is usually influenced by returns from agricultural production, which depend on asset ownership and capacity to produce and market efficiently. Hence, the decision to be in a certain marketing outlet may directly influence household income. Narayanan (2012) applied the utility theory to assess the welfare effects of participating in contract farming schemes. He noted that marketing outlet offers different prices and sales services in southern India thus, are very important in determining smallholder's welfare gains.

Warning and Key (2002) determined the impact of contract farming for peanut growers. In their study, they found that farmers in Senegal who were contracting had higher income compared to those who did not participate. Similarly, Katchova (2008) applied propensity score matching to correct farmer's selling to contractor (contract farming) depending on whether the contracted group has alternative marketing choice or not. He revealed that there was absence of price distortion in the six different agricultural commodity markets of contract farming where there.

2.6 Econometric model specifications

Most of the economic literature reviews reveals various methods used to analyze choice decision studies. They are normally econometric in nature in which probit and logit models are seen to be widely used. Several studies have adopted these models in analyzing the factors influencing choice of milk marketing channels. The two methods generally are used to model decisions which involve two complete mutually exclusive alternatives such that when one is chosen the other is completely left out. The Logit and Probit models may give similar results provided that the samples are large enough and most of the observations fall near the tails. However, it should be noted that unlike in the probit model, in the Logit model, the dependent variable is the log of the odds ratio which is a linear function of the regressors and follows the logistic distribution (Gujarati, 2008; Anjani, 2011).

The above two methods have been widely used by many researchers to analyze the smallholder decision making when faced with two alternatives. However, choice decisions are not only bound between two alternatives but can be more. For instance, in this study, a farmer is faced with different milk marketing outlets that include milk cooling plants, processing plants (cooperatives), neighbours, milk hawkers and farmers can decide to choose only one or more of these outlets leaving the others. These makes probit and Logit models less accommodative. In such cases advanced models called multinomial Logit (MNL) model can be used. According to Ying (1996), an extension of the binary Logit model to cases where the dependent variable has more than two categories is said to be a multinomial Logit model. When the dependent variable categories are not ordered this model is an appropriate technique (Gujarati, 2008). Mburu *et al.* (2004) cited that MNL model is similar to the Binary Logit model, except that the dependent variable in this case has multiple discrete outcomes instead of just two. This estimation technique is very similar to the Binary Logit model, except that it does not predict the odds of 1 or 0. Rather it predicts the odds of the different outcomes on the baseline outcome.

The current study endeavored to analyze such factors based on three distinct outlets that a dairy farmer can select from. Recent empirical studies assume that farmers consider a set of possible outlets and choose the particular outlet that maximizes his/her own utility. Thus, the choice decision is intrinsically multivariate and attempting univariate modeling excludes useful economic information contained in interdependent and simultaneous choice decisions (Dorfman, 1996; Teklewold *et al*., 2013). Thus multivariate Probit (MVP) technique is employed to model simultaneous and interdependent channel decisions by dairy producers.

This multivariate probit approach recognizes the likely correlations between the farmer's decisions across the different channels for the same farm household through unobserved characteristics. It simultaneously models the influence of the set of descriptive variables on each of the different channels, while allowing the unobserved and unmeasured factors (error terms) to be freely correlated. Sources of correlation may include complementarities (positive correlation) and substitutability (negative correlation) between different channels.

2.7 Measures of gross margin

According to Kohls and Uhl (2002), gross margins refer to the difference in mean earnings returned from invested resources. It is a performance measure that replicates the number of units, the prices received per unit and total expenses involved in producing the same units. Different researchers such as Kibet *et al*. (2011), Kohls and Uhl (2002) identified different measures of determining farm profitability of farmers in different marketing channels. Profitability of marketing channels can be determined using five basic methods of economic analysis namely; Gross margin analysis (GMA), Partial Budgeting Analysis (PBA), Cost Effective Analysis (CEA), Cost Utility Analysis (CUA) and Cost-Benefit analysis (CBA) (Emery *et al.*, 1987; Kohls. *et al.,* 2002). In complete enterprises, both PBA and CBA are used to determine the profits of enterprises because the fixed costs are always allocated and the records are well kept, unlike for gross margin analysis where only the outputs and variable costs are allocated to individual enterprises. Kibet *et al*. (2011) argued that the partial measures of profitability (gross margin, budgeting analysis and returns per unit of input) do not obey the law of diminishing returns to scale. However, he noted that gross margin analysis was more preferred because of its simplicity and flexibility for farmers to interpret. In addition, its computation requires only three types of information; farm gate prices, variable costs per unit of production inputs and livestock output sales level which can easily be get from the farmers. The current study therefore, employed gross margin analysis to calculate gross margins of farmers in the different marketing outlets.

2.8 Theoretical framework

Farmer's choice decision of milk marketing outlet in an expected utility framework is based on random utility theory (Greene, 2000). This framework assumes that different farmers assess their expected utilities for their own marketing outlet. The farmer then examines his or her net return distribution by considering the certainty equivalent for each marketing outlet by calculating its associated cost. The cost is the amount that would make the farmer indifferent to deliver to a given outlet. Since smallholder dairy farmer's decision to deliver milk to one outlet and leaving the others is viewed as a multi-choice problem, the decision to deliver to cooling plant or to other outlet depends on the maximum utility or net returns derived from that outlet. This theory was identified as appropriate under the assumption that household i is faced with more than two bundles (Greene, 2000; Gujarati, 2008). A household i faced with a decision to choose from among the different alternatives therefore is perceived to attain a certain level of utility from each alternative based on their characterization as represented in the equation (1)

$$U_{ij} = \beta \mathrm{F}_{\mathrm{ij}} + \varepsilon_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where; U_{ij} is the maximum utility that an individual i derive from choosing $j\,th$ marketing outlet, F_{ij} is a vector of individual characteristics, β is the parameter to be estimated and $\varepsilon\, i\, j -$ is the error term.

Since individual`s utility cannot be observed, but we can observe some of the attributes of the marketing outlet chosen by the decision maker and/or individual’s characteristics such as household and personal characteristics, the utility therefore can be decomposed into deterministic (W_{ij}) and random (ε_{ij}) parts as given in equation (2)

$$U_{ij} = W_{ij} + \varepsilon_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where U_{ij} is the channel choice, W_{ij} is the indirect utility and ε_{ij} is the random error term. The choice strategy is given by probability of choosing one outlet and leaving the others or also chose to deliver to more than one outlet.

2.9 Conceptual framework

Dairy farmers’ decision of a milk outlet choice is assumed to be influenced by socio-economic characteristics of the farmer such as age, marital status, gender, experience, household size, farm size, off-farm activities and education level. It is also assumed to be influenced by the background factors that include institutional factors such as; access to credit, prices, group membership, repayment period, distance to market and milk volume. These factors when interacts together influences the farmers to choose a marketing outlet. The chosen outlet therefore is perceived to increase income, thus improving the livelihood of smallholder milk producer. The conceptual framework for this study therefore is shown figure (1)

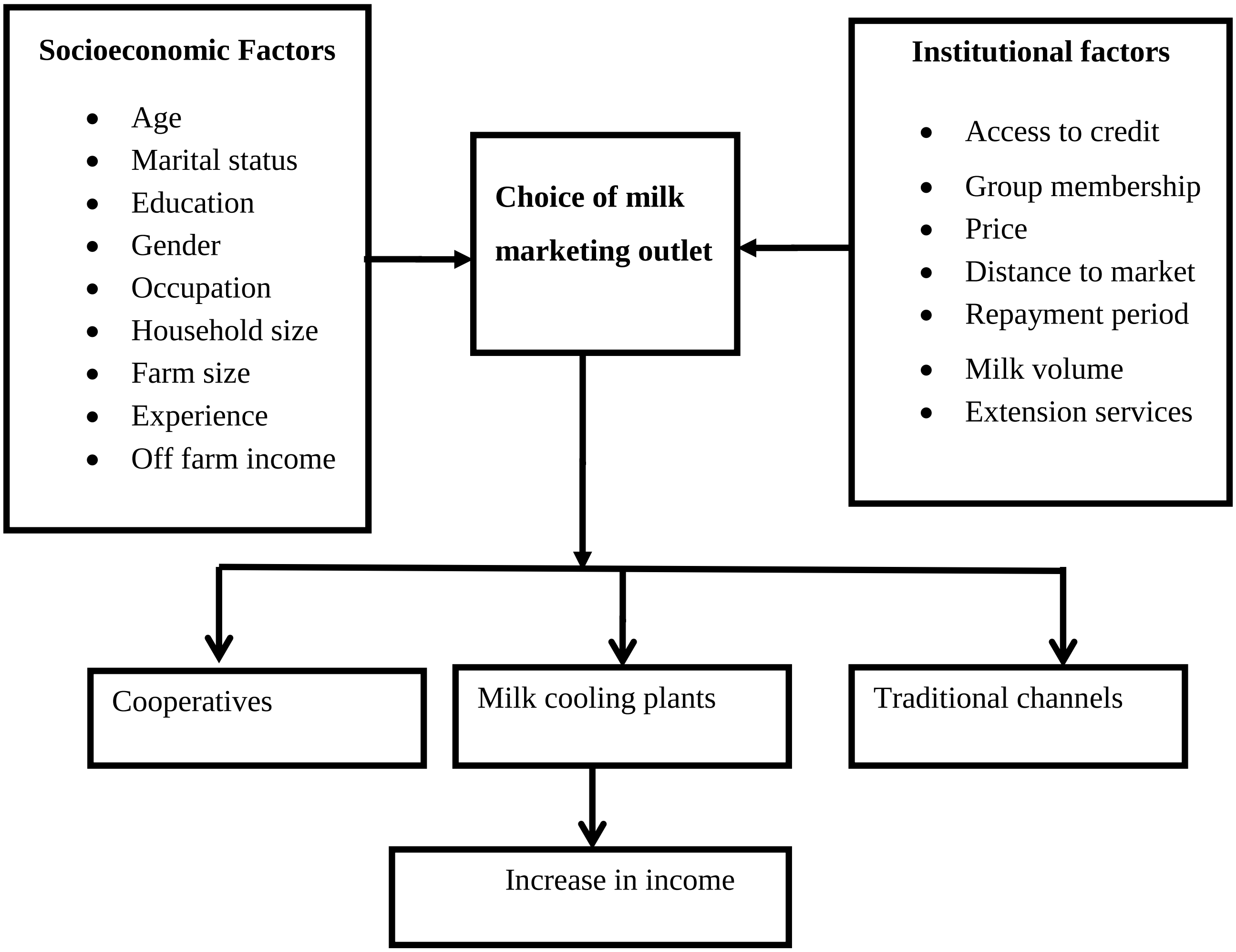

Figure 1: Conceptual framework

Source: Authors' conceptualization.

CHAPTER THREE

METHODOLOGY

3.1 Description of the area of study

This study was conducted in Sotik Sub-County, Bomet-County, Kenya (Figure 2). The area lies between latitudes 0º 29' and 1º 03' South and between longitudes 35º 05' and 35º 35' East. The overall landscape of the Sub-County is characterized by undulation topography that generally slopes towards the west. Rivers flow from the North East to the West. Most of the rivers originate from the South West Mau forest; traverse the Sub-County before joining major rivers and eventually emptying into Lake Victoria. It lies between an altitude of 1400-1800m above sea level. It borders Chepalungu Sub-County to the West, Borabu Sub-County to the South, Bomet Central to the East and Bureti Sub-County to the North (IEBC, 2010). As per the report of Bomet County development profile 2013, Sotik Sub-County covers an area of 446.20 Square Kilometres with a population density of 167289 individuals (KNBS, 2009). Rainfall pattern is bimodal, with long rains received between March and May, while the short rains are received between October and December with recorded annual rainfall ranging between 1000 mm and 1800 mm per annum. Temperatures range from a minimum of 12.9^{o}C to a maximum of 24.6^{o}C with an average of 18.0^{o}C.

Most of the dairy production in Kenya is concentrated in Rift Valley and Central regions. It is estimated that 53% of dairy cattle is found in Rift Valley region and 25% in Central region (Staal *et al*., 2008). Sotik Sub-County is one of the highest milk producing in Rift Valley with an approximate of 19,481 dairy farmers. Of these, 95 percent are small scale dairy farmers (ILO, 2009). This is evidence that the dairy industry is a major player contributing to household incomes of the smallholder dairy farmers in the study area. Cooling plants have also been established in every administrative ward of Sotik Sub-County. Therefore Sotik Sub-County was chosen as the most suitable study area.

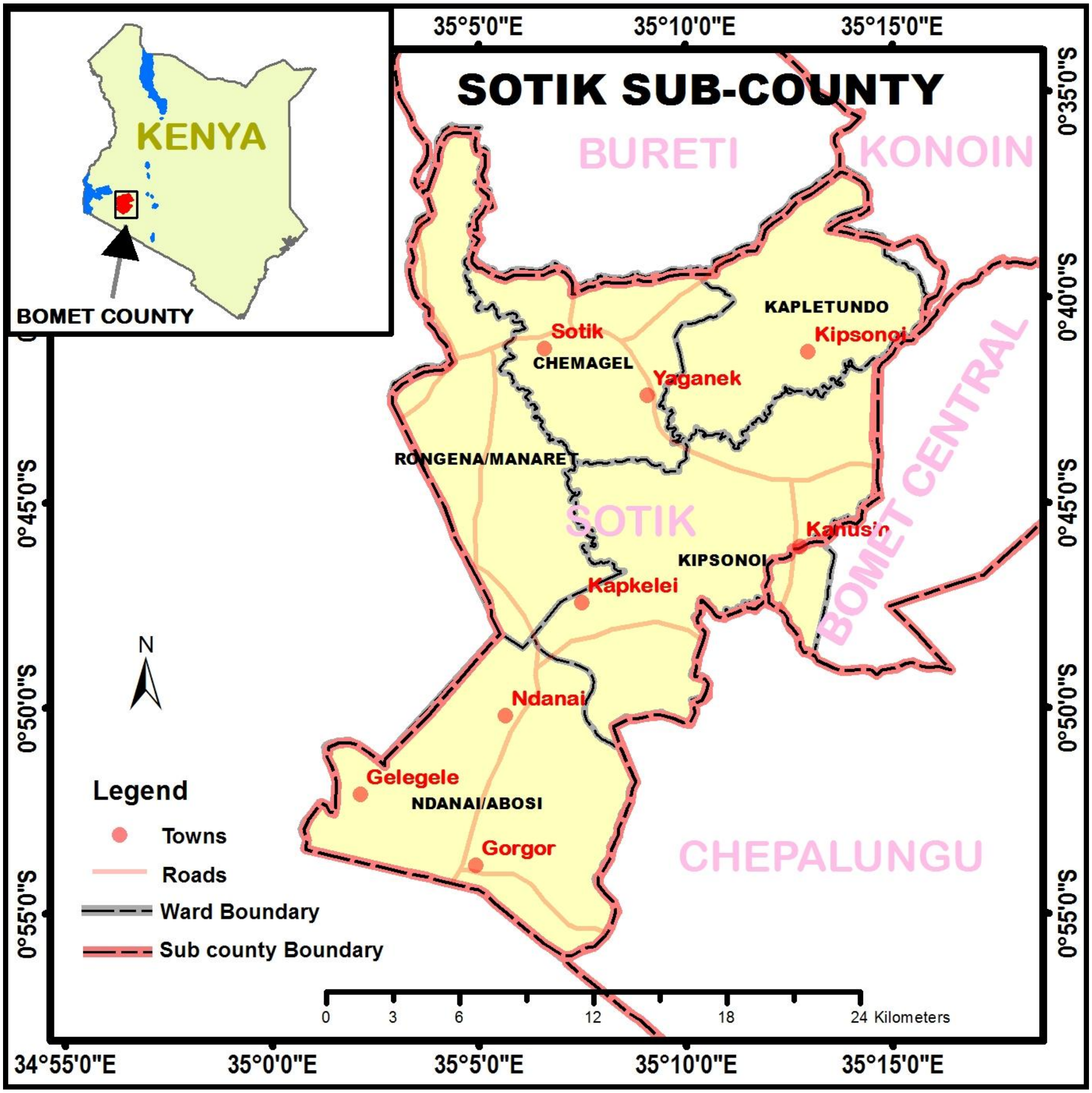

Figure 2: Map of Sotik Sub-County (Ministry of Devolution and Planning, 2013)

3.2 Research design

This study employed a descriptive survey research design. Descriptive survey design is used to gather, summarize, present and interpret information for the purpose of clarification (Orodho, 2002). The research design was particularly appropriate since the study was aimed at collecting information from respondents on the choice of marketing outlet.

3.3 Sample size determination

A sample of 150 farmers was selected from the population of the smallholder dairy farmers delivering milk through the existing marketing outlets in Sotik Sub-County. The sample was drawn from 5 wards of the Sotik Sub-County using probability sampling method. The following formula was employed to come up an appropriate sample for the study,

$$n = \frac{Z^2pq}{d^2} \quad \text{(Fishers } et\ al., 1999)$$

Where; n = Desired sample size (if the target population is greater than 10,000), Z = confidence level (α = 0.05); p = the proportion in the target population estimated to have characteristics being measured, $q = (1 - p), d$ = allowable error. Hence; Z =1.96, $p = 0.11 = \left(\frac{19481}{167289}\right), q = 0.89$ and $d = 0.05$

$$n = \frac{(1.96)^2(0.11)(0.89)}{(0.05)^2} = 150$$

3.4 Sampling procedure

The population of this study comprised small scale milk farmers from which samples was drawn from farmers who keep dairy cattle and sell milk through an existing milk marketing outlet. Multistage sampling procedure was used. In the first stage, purposive sampling was used to select Sotik Sub-County because dairying is a major economic activity for majority of the people in the study area. In the second stage, the 5 county assembly wards were also purposively selected because they have existing installed cooling plants. Lastly, dairy farmers were randomly selected from each ward. The estimated number of farmers from each ward selected therefore was determined using Bowyles` formula of probability proportional to sample size,

$$n = \frac{\text{Sp}}{\text{TP}} X \text{ Tss} \quad \text{(Bowyles, 1995)}$$

Where n = desired sample size, Sp = sample size of selected ward, TP = Total population of the study area, Tss = Total sample size

Table 1: Sample proportions per ward

Ward	Population size	% of population selected
Ndanai	37149	$\frac{37149}{167289}\text{x}150 = 33$
Kapletundo	40368	$\frac{40368}{167289}\text{x}150 = 36$
Rongena	32234	$\frac{32234}{167289}\text{x}150 = 29$
Kipsonoi	22340	$\frac{22340}{167289}\text{x}150 = 21$
Chemagel	35194	$\frac{35194}{167289}\text{x}150 = 31$
TOTAL	167289	150

Source: Kenya National Bureau of Statistics (2010).

3.5 Data collection and data analysis

This study used both primary and secondary data collection. Primary data was collected through interviews with the help of semi-structured questionnaires. Secondary data relevant to the study was obtained from various sources that include publications, project reports, journals, relevant websites and books. These sources were acknowledged. Data was analyzed using STATA and SPSS computer programs.

3.6 Analytical framework

Objective 1

To analyze the factors influencing dairy farmer's decision to deliver milk to a cooling plant or to other milk market outlet, multivariate probit model was employed. Multivariate probit can be derived from the assumption of random utility model of utility maximization which assumes that if an individual i makes a choice j from a complete list of channel bundle then the utility of that particular channel is maximum (McFadden, 1983).

We let the utility associated with the three outlets denoted by; Z_{io}^{CP}, Z_{io}^{CO} and Z_{io}^{VN}, respectively. The utility levels in a marketing outlet are a function of personal characteristics and household composition. For each outlet, Z_{iO}^{U}, the following utility function is specified as, $Z_{iO}^{U} = \alpha^{u} + X_i\beta_i$. Where, Z_{iO}^{U} is the utility derived from a given marketing outlet, X_i are the individual characteristics and β_i are the deterministic.

The empirical specification of choice decision over the three groups of marketing outlets can be modeled in two ways, either by multinomial or multivariate regression analysis. One of the assumptions of multinomial models is that the independence of irrelevant alternatives, that is, error terms of the choice equations are considered mutually exclusive (Greene, 2003). However, the choices among the marketing outlets are not mutually exclusive as farmers can sell their milk to more than one outlet at the same time. Therefore, the random error components of the information sources may be correlated. Multivariate probit model was thus found to be the best model because it allows for the possible contemporaneous correlation in the choice selected among the three outlets simultaneously. To determine factors that influence the farmer's decision, the use of random effects to model the dependence across sequential decisions is therefore necessary. Household draw realizations of the three latent variables from a known joint distribution, this decision can be modeled using multivariate probit framework. Multivariate Probit estimation has already been used in a number of studies that evaluate factors that influence decisions of marketing outlets and adoption when farmers are faced with more than two alternatives. For instance, Jenkins *et al*. (2011) used this approach to evaluate factors that affect cotton producers' adoption pattern of different information sources i.e. private, extension and media. They argued that modeling farmers decisions using a multivariate probit framework allows for increased efficiency in estimation in the case of simultaneity of decisions. Thus this study adopted the same model to determine the choice selection of smallholder dairy farmers.

Empirically, the model was specified as follows;

$Z_{i1}^{CP} = X_{ij1}\beta_i + \varepsilon_{ij1}$

$Z_{i2}^{CO} = X_{ij2}\beta_i + \varepsilon_{ij2}$

$Z_{i3}^{VN} = X_{ij3}\beta_i + \varepsilon_{ij3}$…………………………………………………………………….. (3)

Where the error terms represented by $\varepsilon_{ij1\ldots3}$ have a joint multivariate normal distribution Z_{i1}^{CP} =1, if a household chooses to deliver to cooling plant; Z_{i2}^{CO} =1, if a household chooses to deliver to Cooperatives, Z_{i3}^{VN} =1, if a household chooses to deliver to vendors/ neighbours, X_{ij} are the vector of factors influencing the choice of milk outlet. The decision to deliver milk to any of the three outlets may be correlated, thus the elements of error terms might experience stochastic dependence. Therefore, the multivariate probit model equation is given as;

$Z_{ij1} = X_{ij}\beta_i + \varepsilon_{ij}$……………………………………………………..…………………... (4)

Z_{ij} (J=1.., 3) denotes cooling plant, cooperatives and milk vendors faced by household $i\ th$ (i=1……150), X_{ij} represents vector of observed variable that affect the choice decision of a dairy farmer, while β_i denotes the $1xk$ vector of unknown parameters that would be estimated and ε_{ij} represents the unobserved error term.

This model assumes that the error terms in the three latent equations jointly follow a multivariate normal distribution. Under this assumption, a multivariate probit (MVP) model that jointly represents the delivery decisions for the three outlets was used. The MVP specification with potentially non-zero off-diagonal elements allows for correlations across the disturbances terms of the three equations of the outlets which embody unobserved characteristics for the same individuals. While the MVP model has the UVP as a special case, it now allows for the knowledge on an individual's delivery decision in one outlet to help predicting his/her probability of delivering to a related outlet. The implicit function form therefore is given in equation (5)

$Y_{ij} = \alpha + \beta 1\ AGE + \beta 2\ \mathrm{GEND} + \beta 3\ \mathrm{MS} + \beta 4\ EDUC + \beta 5\ EXP + \beta 6\ HS + +\beta 8\ FMZ + \beta 9\ ACCR + \beta 10\ RP + \beta 11\ \mathrm{DIST} + \beta 12\ VM + \beta 13\ \mathrm{PR} + \beta 14\ \mathrm{GRPM} + \beta 15\ \mathrm{EXST} + \beta 16\ \mathrm{OFFM} + \beta 17\ OCUP + \varepsilon$………………………………………………………………. [5]

Where Y_{ij}^{*} is the marketing outlet choice, α – Constant, β 1,2,3 ...…17 −Factors to be determined and ε- error term.

Table 2: Variables used in the multivariate probit model

Variables	Code	Variable measurement	Expected sign
Age	AGE	Continuous(years)	+/−
Gender	GEND	Dummy (1=male, 0=female)	+/−
Education	EDUC	Continuous (number of schooling years)	+
Marital status	MS	Categorical (1=married 2=unmarried, 3=widow,4=separated)	+/−
Experience	EXP	Continuous (number of years)	+
Household size	HS	Continuous (household number)	+/-
Farm size	LSIZE	Continuous (size in hectares)	+
Access to credit	ACC	Dummy (1=Yes, 0=No)	+
Repayment period	RP	Categorical (1=weekly,2=monthly,3=(other)	+
Distance to the market	DIST	Continuous (kilometer)	+/−
Volume of milk	VM	Continuous (liters)	+
Price	PR	Continuous (KES per litre)	+
Group membership	GRPM	Dummy (1= Yes, 0=No)	+
Extension service	EXTS	Dummy (1= Yes ,0=No)	+
Off farm	OFFM	Dummy(1=Yes ,0=No)	+
Occupation	OCUP	Dummy(1=employed, 0=not employed)	+/−

Independent variables (1=milk cooling plants, 2=cooperative 3=Vendors/Neighbours

<u>Objective 2</u>

To address objective two of this study, gross margin analysis (GMA) was done. GMA according to Msangi and Mlulla (2000) can be defined as the difference between the total revenue and the total operating expenses or total variable costs. It is one of the most commonly used analytical techniques for planning and analysis of various projects by advisors, researchers, and consultants (Emery *et al*., 2004).

Previous studies have used varying approaches to measure profitability of milk marketing. According to Emery *et al*. (2004), GMA is used to measure the profitability of an enterprise and also used as a mean of selecting the best farm plans. The size of gross margin depends on the market structure, services provided, market price, perishability of the product as well as the distance between producers and consumers. This may be influenced by market information especially over the short run.

The advantages of the GMA in economic analysis are that; it is easy to understand and utilize the rational logical interrelations of economic and technological parameters; it helps in predicting rational alternatives for the operational structure of an enterprise or individual farmer (Emery *et al*., 2004; Kibet *et al*., 2011). Furthermore GMA is an easy way to understand the profitability of an enterprise as it shows an effective management that can bring profits from sales (McClure, 2004). Since calculation of depreciation has often been difficult to carry out due to the ambiguity in relation to the nature of estimating the lifespan of fixed assets, appreciation and salvage value in many firms, it necessitates the use of GMA models.

In this study, gross margin analysis was used to compare profitability of dairy farmers delivering through milk cooling plants and those that do not. The use of gross margins is based on assumptions that all fixed inputs are not treated as inputs used in production and marketing due to limited information. In addition, dairying being a long time investment, dairy farmers may lack asset records; hence production strategy and prices that are prevailing during production period was used. According to Johnsen (2003), GMA can be modeled in equation 6 as;

GM= TR-AVC……………………………………………………………………………. (6)

Where; GM = Gross margin (KES/unit)

TR= Total revenue (KES/unit)

AVC=Average variable costs (KES/unit)

Objective 3

To answer the third research question, the analytical method employed was drawn from the work of Ravallion (2001) and Bernard *et al*. (2008). According to these scholars, one way to obtain robust impact assessments is by use of Propensity Score Matching (PSM). This model of analysis is a two-step procedure whereby in the first stage the probability model of participation is estimated to calculate the propensity score of each household's participation. In the second step, each farmer delivering his/her milk to cooling plants is matched with the one which does not with similar propensity score in order to estimate the average treatment effect for the treated (ATT). In this study it refers to the average income effect of dairy smallholder farmers who are delivering milk to cooling plants.

The outcome of farmers involved in milk cooling plants had they not deliver their milk to the cooling plant or the outcome of those who did not deliver had they participated may not be possible to observe hence is difficult to estimate the effect of milk cooling plants on household income. Therefore, this problem can be addressed by assigning households to treatment and control in experimental studies but in this case of non-experimental study, milk cooling plants is not evenly distributed but rather households have to make a choice.

The decision of the farmer to deliver to cooling plant or not may be based on self-selection since every dairy farmer has different characteristics and this may affect the involvement decision and welfare outcome. The estimated propensity score, for subject i $(i = 1, \ldots, N)$ is therefore conditional probability of being assigned to a particular treatment given a vector of observed covariates ix_i as proposed by Rosenbaum *et al.,* (1985).

Where, $Y_i = 1$ for treatment (delivering to cooling plants) $Y_i = 0$, for control (not delivering to cooling plants) and x_i= Vector of observed covariates for the i_{th} subject.

The effect of a treatment for an individual i, noted δ_i is defined as the difference between the potential outcome in case of treatment and the potential outcome in absence of treatment:

$\delta_i = Y_i 1 - Y_i 0$……………………………………………………………………………… (7)

To calculate the average treatment on the treated (ATT), the actual income from milk cooling plants and its counterfactual (not delivering to cooling plants) is also calculated. Average treatment on untreated (ATU) is the difference between the actual (observed) and the counterfactual income for those not delivering to cooling plants. Therefore the impact across all the individuals in the population is obtained by finding the Average Treatment Effect (ATE).

$ATE = E\,(\delta) = E\,Y1 - Y0$ (.)………………………………………………………… (8)

Where; E (δ) represents the average (or expected value).

Average Treatment Effect on the Treated, or ATT, which measures the impact of milk cooling plants on those individuals who delivered milk to cooling plants is represented as

$ATT = E\,(Y1 - Y0 \mid D = 1)$……………………………………………………………… (9)

The Average Treatment Effect on the Untreated (ATU) measures the impact that milk cooling plants would have had on those who did not deliver to cooling plants (counterfactual)

$ATU = E\,(Y1 - Y0 \mid D = 0)$………………...…………………………………………… (10)

The problem is that all of these parameters are not observable, since they depend on counter-factual outcomes. For instance, using the fact that the average of a difference is the difference of the averages, the ATT can be rewritten as:

$ATT = E\,Y1\,(|\,D = 1) - E\,Y0\,(|\,D = 1)$………………………………… …………… (11)

The second term ATT is the average outcome that the treated individuals would have obtained in absence of treatment, which is not observed. However, the value of Y0 for the untreated individual is observed. Thus, we calculated:

$\Delta = E\,Y1\,(|\,D = 1) - E\,Y0\,(|\,D = 0)$ ……………………………………..………. (12)

The difference between Δ and the ATT can be obtained by adding and subtracting the term,

$\Delta = ATT + E\,Y0\,(|\,D = 1) - E\,Y0\,(|\,D = 0)$…………………………………… (13)

$\Delta = ATT + SB$

SB is the selection bias: the difference between the counterfactual for farmers delivering to cooling plants (treated) and the observed outcome for the control farmers (untreated). If this term is equal to 0, then the ATT can be estimated by the difference between the mean observed outcomes for treated and untreated.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the study findings. It begins by presenting descriptive statistic results of significant variables on socio-economic characteristics such as; age gender, education level, household size, price, distance, access to credit, extension service and group membership in relation to choice of marketing outlet decision of smallholder dairy farmers. It also presents gross margin results of farmers delivering milk to different marketing outlets and multivariate probit results for choice decision as well as the propensity score matching results of delivering milk to cooling plant on household income.

4.2 Socio-economic characteristics in relation to choice decision

Table 3 shows that 68.24%, 75.36% and 60% of the male headed households used milk vendors/neighbours, cooperatives and cooling plants, respectively as a choice of milk marketing outlet while, 31.76%, 24.64% and 40% of the female headed used vendors/neighbours, cooperatives and cooling plants, respectively. The results show that the number of males in the three outlets is more than that of females. The Chi^2 result showed that there was no significant association between the gender and market outlet decision. Hence, gender distribution was almost similar in the three outlets.

Dairy farmers have either accessed extension services from different extension officers or not. The results of this study revealed that 28.24%, 81.16% and 71.11% of farmers using milk vendors, cooperatives and cooling plants respectively had access to extension services while 71.76%, 18.84% and 28.89% of farmers using milk vendors, cooperatives and cooling plants, respectively had no access (Table 3). The Chi^2 result confirms that the association between choice decision and access to extension service was significant at 95% confident level.

In relation to credit access, 34.12%, 68.12% and 66.67% of farmers selling milk to vendors, cooperatives and cooling plants, respectively had access credit services while 65.88%, 31.88% and 33.33% of the farmers selling to milk vendors, cooperatives and cooling plants, respectively had no access to credit services (Table 3). The Chi^2 result shows that the association between access to credit and choice of milk outlet was significant at 90% confident level. An access to credit plays an important role in empowering the farmers to choose a channel which can help in providing loans for emergencies like fees, hospital bills or livestock feeds (Mburu *et al.,* 2007; Luoga *et al.,* 2010). The results of the group membership showed that, 36.47%, 39.13% and 64.44% sell their milk to milk vendors, cooperatives and cooling plants, respectively, while 63.53%, 60.87% and 35.56% were not members to a group (Table 3). This suggests that most farmers have registered as group members in cooling plants as compared to milk vendors and cooperatives. The Chi^2 result shows that the association between market outlet decision and group membership was significant at 90% confident level.

Table 3: Categorical respondents' socio- economic characteristics (%)

Variables		Milk vendors/ Neighbours (N=85)	Cooperatives (N=69)	Cooling plant (N=45)	Chi^2
Gender					
	Male	68.24	75.36	60.00	3.0871
	Female	31.76	24.64	40.00	
Group Membership					
	NO	63.53	60.87	35.56	15.137*
	YES	36.47	39.13	64.44	
Access to Credit					
	NO	65.88	31.88	33.33	0.3401*
	YES	34.12	68.12	66.67	
Extension Service					
	NO	71.76	18.84	28.89	22.575**
	YES	28.24	81.16	71.11	

Asterisks **, * represents significance levels at 5% and 10 %, respectively.

Table 4 presents the results of age, household size, price, education level and distance to the market characteristics of the smallholder dairy farmers in the milk market. The results show that the minimum household size was 1 member while the maximum was 9 members. The mean household size for farmers delivering to cooling plants was 5.62 members, while that of cooperatives and milk vendors/neighbors were 4.94 and 5.14 members, respectively. The means are nearly the same as that of Kenya's national mean of 5 members per household (CBS, 2005). In terms of age, the minimum and maximum ages of farmers in the milk market were 20 and 74 years, respectively. It is revealed that there was more involvement of middle age group of dairy farmers in the study area. Dairy farmers delivering milk to cooling plants had a mean age of 33.24 years, while farmers selling to milk vendors/neigbours and cooperatives were 36.88 and 35.33 years, respectively. This implies that many of respondents in the survey area were mature people who could actively engaged in milk production and can make rational and informed decisions on choice of marketing outlet to use. Prices offered in the three outlets ranged from KES 25 to KES 30 per litre. This implies that the milk prices are unstable in the three outlets. Dairy farmers received a mean of KES 27.74, KES 28.42 and KES 29.33 per litre of milk when sold to the milk vendors, cooperatives and cooling plants, respectively. Education level of the farmers on the other hand was examined by getting the number of schooling years a farmer has attained in their life. Smallholder milk producers captured in the study showed that most of them had gone to school. Farmers selling milk to cooling plants had a mean of 11.56 schooling years compared to 10.4 and 11.03 schooling years of milk vendors/neighbours and cooperatives, respectively. The difference in the schooling years among the sampled households implied that market information on which marketing outlet to use is of important benefit to the smallholder milk farmers. Makhura *et al*. (2001) argued that human capital represented by the household's head formal education increases his understanding of market dynamics hence, improving decision on the amount of output sold to the market.

Table 4: Continuous respondents' socio-economic characteristics

	Cooling plant (N=45)				Cooperatives (N=69)				Vendors/neighbors (N=85)			
Variables	Min	Mean	max	Std	min	mean	Max	Std	min	Mean	Max	Std
Age(years)	20	33.24	39	7.23	20	35.33	63	9.42	20	36.96	74	10.44
Schooling years	8	11.56	16	2.28	3	11.03	16	2.6	1	10.4	16	3.21
Price per litre (KES)	25	29.33	30	1.04	26	28.42	30	0.98	25	27.74	30	1.73
Distance to market(Km)	0.5	1.96	7	1.41	0.5	2.84	10	1.9	0.1	0.9	10	1.71
Household size	1	4.94	9	1.92	1	4.94	11	2.05	1	5.14	10	2.12

NB: min, max, and std, represent minimum, maximum and standard deviation, respectively.

4.3 Factors influencing the choice decision of marketing outlet

Table 5 shows the factors influencing smallholder dairy farmer's milk outlet choice decision based on a multivariate probit model. The Chi^2 statistics with a value of -177.83 showed that likelihood ratio is highly significant ($P < 0.000$). This suggests that the Multivariate Probit model had strong explanatory power and hence the model fits the data reasonably. Of the 17 variables included in the model, only nine variables (age, gender, education, household size, price, distance, group membership, credit access and access to extension services) were found to significantly influencing the farmers' choice decision of a cooling plant.

Table 5: Multivariate probit results of factors influencing the choice decision of market outlet

	Milk vendors/Neighbours (N=85)			Cooperatives (N=69)			Cooling plants (N=45)		
Variables	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z
Total land size in hectares	0.0045	0.0565	0.9370	-0.0117	0.0545	0.8290	0.0534	0.0805	0.5070
Land under dairy in hectares	0.0148	0.2634	0.9550	0.0803	0.2358	0.7330	-0.1107	0.3053	0.7170
Off-farm income(KES)	0.2336	0.0324	1.0000	0.0345	0.0567	0.7960	0.0345	0.4566	0.4010
Occupation status	-1.0406	0.4182	0.5466	0.4309	0.4029	0.2850	-0.1374	0.6074	0.8210
Number of family members	0.0117	0.0626	0.8520	-0.1125	0.0605	0.9670	-0.1741	0.0888	0.0500**
Group membership	0.7831	0.3239	0.3478	0.0148	0.2733	0.9570	0.8207	0.3546	0.0210**
Schooling years	0.1384	0.0577	0.0170**	0.1401	0.0499	0.0844*	0.1512	0.0769	0.0490**
Marital status	-0.2031	0.1830	0.2670	0.0871	0.1631	0.5930	0.1194	0.2096	0.5690
Gender	0.0145	0.2968	0.0961*	0.2682	0.2778	0.0640*	0.6224	0.3614	0.0850*
Age (years)	0.0266	0.0199	0.1810	0.1289	0.0173	0.0950**	-0.1447	0.0257	0.0820*
Experience (years)	0.0156	0.0261	0.5500	0.0526	0.0227	0.3457	0.0372	0.0330	0.2600
Total number of cattle	-0.2010	0.0859	0.0190**	0.0354	0.0829	0.6690	0.0706	0.1102	0.5220
Volume of milk sold	0.0290	0.0222	0.1920	0.0118	0.0228	0.6060	0.0240	0.0270	0.3750
Price per litre of milk(KES)	-0.3928	0.1058	0.0000***	0.1261	0.0865	0.1450	0.4968	0.1319	0.0000***

Distance to marketing point (Km)	-0.2174	0.0725	0.0030***	0.2792	0.0790	0.0000***	-0.2214	0.1337	0.0980*
Contract	0.2946	0.5514	0.5930	-0.4631	0.5491	0.3990	-0.9818	0.7251	0.1760
Repayment period	-0.7855	0.3041	0.0100***	0.3516	0.2503	0.1600	0.0931	0.3578	0.7950
Access to credit	0.0808	0.2894	0.0070***	0.4536	0.2657	0.0050***	0.1344	0.3171	0.0760*
Extension services	0.1159	0.3314	0.7270	0.2650	0.3099	0.0360**	0.4405	0.4068	0.0290**
Constant	14.9113	3.7154	0.0000	-4.8954	3.2362	0.1300	13.5133	4.4974	0.0030***

Number of observations = 150, Wald chi2 (57) = 121.51, Log likelihood = -177.832 Prob> chi2 = 0.0000

The asterisk ***, ** and * Represents 1%, 5%, and 10% significant levels, respectively

.

Age of the farmer had a negative and significant influence on the choice of cooling plant outlet at 90% confident level (Table 5). A unit increase in the age of the household head reduces the likelihood of the household delivering to cooling plant by 14.4%. This suggests that, the older the household head becomes, the less likelihood of delivering to cooling plant. This was expected because older farmers are more reluctant to sell their milk to a new market since their planning horizon tends to decrease as the age increases (Arega *et al.,* 2007). Additionally, younger farmers are more receptive to new ideas in the market and are less risk-averse (Barret *et al*., 2010). In other words, the results explains that younger farmers are more inclined with the cooling plants and are able to cope with its demands, ability to understand transactions costs and have indebt trust in cooling plants. This finding supports the results of Vijay *et al.* (2009) who noted that the household head's age is negatively related to participation of an old farmer in modern channels and statistically significant in private dairy channels. Similarly, Quddus (2012) and Staal *et al*. (2000) found that the age of the farmer was negatively influencing the decision to use a new technology.

The price of milk was statistically significant in the choice of cooling plant, cooperatives and milk vendors/neighbours outlets. With an increase in price by one shilling, a dairy farmer is 49.68% more likely to sell to cooling plant, 12.61% to cooperatives and 39.68% less likely to milk vendors/ neigbours. This could be due to the milk prices which are unstable in the three outlets. The results suggests that dairy farmers who deliver their milk to cooling plants incur neither higher transaction cost like cooperatives nor do they receive low prices like those selling to milk vendors/neighbours. Milk producers are therefore more responsive to sell to cooling plants because the prices offered are much higher than their counterparts which are less rewarding (KES 29.33 per litre in cooling plants compared to KES 27.74 and KES 28.42 per litre when sold to milk vendors and cooperatives, respectively). The positive sign on its coefficient justifies that the higher the price, the more the profit made and hence the more it creates an incentive for farmers to deliver their milk through cooling plants compared to cooperatives and milk vendors/neighbours. This is consistent with the results of Jari (2009), who noted that when price of a product increases in a marketing channel, there is an increase in participation in that particular channel. However, another expectation would be that, dairy farmers may not be considering prices and are likely to sell to cooperatives or milk vendors/neighbours than to milk cooling plants. This is contrary to the finding of this study and may be justified by the reasons above that farmers delivering milk to cooling plants, sell at a better price than that of their counterparts.

Distance to milk collection center had a negative and very significant effect on the decision of the smallholder milk farmer to deliver milk to cooling plant at 90% confident level. The negative sign implies that, the longer the distance to the cooling plant, the higher the time taken to deliver the milk. This reduces the likelihood of the farmer selling milk to a cooling plant and increasing the likelihood of selling to other outlets which are nearby. Most dairy farmers prefer nearby market point since it reduces time wastage, saves on transport costs and also reducing milk spoilage in places where roads are in poor conditions, especially during rainy seasons. In other words smallholder milk producer preferred selling milk to other outlets when long distances to the cooling plant exist (17.5 % less likely to sell to milk cooling plants than to cooperatives and milk vendors/neighbours). These findings collaborate the finding of Musemwa *et al*. (2007), who demonstrated that accessibility and reliability of the market constitute major attractions for auction sales among smallholder dairy farmers. The findings are also in line with other studies that, the longer the distance, the higher the transportation cost and the higher the cost of marketing milk (Mburu *et al.*, 2007; Ogunleye and Oladeji, 2007).

As expected, gender of the household head had a positive and significant influence on the choice of milk cooling plant, cooperative and milk vendors/neighbours. Male-headed households had a higher probability of selling to cooling plants by 62.24%. However, they had a lower probability of selling to cooperatives and milk vendors/neighbours by 26.49% and 1.45%, respectively. The positive correlation implies that male-headed households tend to be risk takers and are capable of searching for new markets in a competitive environment. Conversely, female-headed households are confined with household chores at home, thus hindering them from searching and attending the market environments (Morrison *et al.,* 2007). The finding concurs with the results of Chalwe (2011) and Geoffrey (2014) who argued that female farmers are faced with gender specific issues like time burden that denied them from accessing the best markets for their produce.

The level of education (number of schooling years) of household head was positive and significant among farmers selling milk to cooling plant at 90% confident level. A unit increase in schooling years of the household head increases the likelihood of such a household to sell to cooling plant by 15.12% compared to cooperatives and milk vendors/ neighbours which increases by 14.01% and 13.84 %, respectively. The plausible explanation is that, education of a farmer is regarded as the most important indicator of social change in the society that increases skill and successful implementation of improved production, processing and marketing practice (Omiti *et al.,* 2009). Additionally, education enhances managerial competence to successful implementation of improved technologies, processing and marketing practices (Staal *et al.*, 2006). This finding is in conformity with the findings of Marenya and Barret (2006) who found education to be positively and highly significant factor influencing marketing decision.

Group membership had a positive and significant influence on the choice decision of cooling plant at 99% confident level. The result shows that having membership to a group increases the likelihood of delivering to cooling plant by 82.07%. This can be explained by the fact that most of the cooling plants are managed/ owned by registered group of farmers and selling to these cooling plants requires an individual to be a registered member of the cooling plant. Membership to an organization is a social participation and meant many actions such as people's connection with other foundations which have social and economic benefits to their membership (Anjani, 2011). The result concurred with the finding of Mburu *et al*. (2007) who noted that marketing in a group enable farmers to pull their resources together and taking advantage of economies of scale. Additionally, it is argued that group membership promotes unity and gives a sense of belonging in addition to empowering farmers bargaining and negotiating for better trading terms, thus, leading to reduced transaction costs (Tsourgiannis *et al*., 2002).

Access to extension services had a positive and significant influence on the choice of milk cooling plant and cooperative market outlets. The results of this study indicated that, access to extension service increases the household likelihood of selling its milk to cooling plant by 44.05% and 26.5% to cooperatives at 95% confident level. The implication of the results is that, it is likely that the extension services received by the dairy farmers selling to cooling plants and cooperatives impacted on their high probability of selling milk to these outlets. Farmers who were probed on the accessibility of extension services reported that most of the cooling plants extension officers regularly organize trainings and are available at any given time for consultations compared to cooperatives who reported that the extension officers were rarely available. The positive relationship shows that access to marketing information through the extension services encourages farmers to venture into new innovations (Staal *et al*., 2004). However, it is argued that farmers with higher education level may have superior ability to access and understand more information and technology therefore applying that knowledge to venture in to new opportunities than farmers with lower education (Nyaupane and Gillespie, 2010). The result seems to affirm the notion that extension service acquired by the farmer about marketing increases the farmer’s willingness to participate in the market (Otieno *et al.*, 2009).

Household family size was negatively and significantly influencing the decision to sell milk to cooling plant at 95% confident level. The negative coefficient of the variable shows that as the dairy household size increases by one adult equivalent, the likelihood of selling milk to cooling plant decreases by 17.41 %. The reason behind the observed relationships is that the larger the household size, the higher the consumption of milk and the less the volume of milk is supplied to the market. The results contradicts the findings of Chumo *et al.* (2016) who noted that size of the family had negative and insignificant effect on adoption of milk cooling and cannot determine adoption of innovations.

4.4 Gross margins obtained by dairy producers in the marketing outlets

The gross margin was calculated by subtracting the variable costs from the gross income. Gross income is the volume of milk sold multiplied by the sale price. The variable costs consisted of the cost of fodder (owned produced or bought), commercial feeds, family expenses, labor expenses, deworming, tick control and transport expenses. As it was observed in Sotik sub-County, the milk prices among the three marketing outlets (Cooperatives, cooling plants and milk vendors/neighbors) differed hence affecting the gross margins accrued to farmers operating in the markets.

Table 6 shows the gross margins per liter of milk obtained by dairy farmers delivering their milk to cooling plants, cooperatives and Vendors/neighbours, respectively. It was noted that, there were costs incurred in milk production and marketing by the farmers although it was not easy to quantify the marketing costs because farmers cannot actually keep proper records. This study therefore relied on the farmer's memory over the last one year to determine their gross margins per litre of milk in the choice of the marketing outlet used.

Table 6: Gross margins obtained by dairy farmers in the different market outlets per litre (KES)

	Cooperatives		Cooling plant		Vendors/Neighbours	
Costs variables	Amount	Total	Amount	Total	Amount	Total
Fodder expenses	2044.93		2368.89		1658.82	
owned produced fodder	2550.73		1791.11		1628.84	
Commercial feeds	5300.73		4517.78		4310.00	
Labor Expenses	4214.49		5488.89		4715.29	
Family expenses	2624.64		2231.11		4409.41	
Veterinary services	2812.14		3043.98		2896.94	
Water expenses	842.03		766.66		842.03	
A. I _Services	1213.02		1296.36		1209.41	
Deworming	450.00		608.89		521.64	
Tick control	1862.61		2212.22		2505.00	
Transport expenses	2737.80		1717.80		391.77	
Total variable costs per lactation period		(26,653.12)		(26,043.69)		(25,089.15)
Average milk volume per month	348.6		423.9		318.6	
Average price per litre	28.42		29.33		27.74	
Gross income per lactation Period		89, 164.91		111,896.88		79,541.68
Gross margin Per lactation Period		62,511.79		85,853.19		54,452.53
Gross margin per litre	(62511.79/9/30/28.42)		(85853.19./9/30/29.33)		(54452.53/9/30/27.74)	
		8.15		**10.84**		**7.27**

4.4.1 Effects of delivering milk to cooling plants on gross margins

The gross margins of dairy farmers delivering milk to the three marketing outlets as reported in Table 6 differed. Dairy farmers who sold their milk directly to the cooling plants received a relatively higher prices and gross margin than those who sold to cooperatives and vendors. Dairy farmers obtained a mean price of KES 29.33 per litre and a gross margin of KES 10.84 per litre when sold to cooling plants. The observed difference in returns among these dairy farmers was vastly attributed to the variation in prices paid by the marketing outlets. This implies that the higher the prices, the higher the gross margin. Farmers delivering to this outlet are therefore encouraged by the prices. They are able to sell to cooling plant market outlet because of clear benefits and higher gross margins. Additionally, dairy farmers delivering milk to cooling plants who were probed said that in terms of other services a channel offers, the cooling plant was definitely better placed because they regarded it as a market which they can easily get access to farm inputs like Artificial Insemination services, veterinary services, feeds, breeding, can invest in cooling plants assets and timely delivery of milk to avoid spoilage which is higher in the other channels. Furthermore, it offered training and field visits to farmers regularly. These activities are very crucial in improving the human resource capacity and increasing the milk production as well as maintaining food safety of milk.

The average price of milk and gross margin at cooperative was Ksh 28.42 per litre and Ksh 8.15 per litre, respectively. The gross margin was lower than that of cooling plant (KES 10.84 per litre). This shows that farmers delivering to cooperative received lower prices and incurs more marketing costs as compared to their counterparts. It can be explained by the fact that cooperative farmers may have travelled long distances to collection centers; had to hire labor for transporting milk at a high cost resulting into a significantly higher unit cost of marketing milk as compared to cooling plants farmers who actually incur less costs in transport thus the difference in the gross margins.

Dairy farmers who sold milk to milk vendors/neighbours obtained a mean price of KES 27.74 per litre and a gross margin of KES 7.27 per litre. The gross margin was lower than that of cooperatives and cooling plants. This could be as a result of improved payment by processors in the formal markets. Additionally, the fact that the cooling plants and cooperatives provide more incentives for milk producers compared to milk vendors retains full autonomy on marketing decisions that enable farmers to maximize their profits. Most farmers prefer selling their milk to milk vendors because they get prompt payment in cash and provide access to market outlets in the most remote areas with poor infrastructure, which is then transported to the major processing companies (Kumar, 2010). Additionally, vendors seem to offer opportunities for the small and resource poor milk producers to enhance their income (Kumar, 2010).

4.5 Effects of delivering milk to cooling plants on household income

In order to address the third objective, this study adopted an econometric model which is the propensity score matching (PSM). The model is commonly employed in the impact/effect evaluation studies (Rosenbaum *et al.,* 1985). Under this approach households delivering milk to cooling plants (treated group) were matched with other households that share similar characteristics but do not deliver their milk to cooling plants (control group). Similar to the adoption models in various studies, the whole sample from the survey data was used in computing the propensity score (Beker and Caliendo, 2000; Yashiko, 2010 and Dehinenet, 2014).

4.5.1 Estimation of the probability propensity score

Table 7 presents results of probit estimation of dairy farmers delivering milk to cooling plants. The results show that gender, household size, age, education, group membership, distance and extension services received by a dairy farmer significantly influenced the decision to sell milk to cooling plant. The estimated model appears to execute well for the intended matching exercise. The pseudo-R^2 value was 0.45 (Table 7). This indicates how well the covariates explain the probability of choosing a marketing outlet. A low pseudo R^2 value means that farmers delivering milk to cooling plant do not have much distinct characteristics overall and therefore finding a good match between treated and control households becomes easier. After matching, it is expected that there would be no systematic differences in the distribution of covariates between the treated and the control groups. Therefore, the pseudo-R^2 should be lower than before matching (Caliendo and Kopeining, 2005).

Table 7: Probit Estimation of factors influencing choice decision of cooling plant

Variables	Coef.	Std. Err.	P>z
Gender	0.783	0.397	0.049**
Age	-0.054	0.031	0.083*
Marital status	0.029	0.217	0.895
Education level	0.138	0.079	0.081*
Household size	-0.151	0.090	0.094*
Occupation	-0.007	0.592	0.990
Size of the land	0.052	0.085	0.538
Off-farm income	0.000	0.000	0.314
Experience	0.041	0.034	0.234
Contract	-0.857	0.949	0.366
Group membership	0.829	0.392	0.035**
Milk volume	-0.815	0.842	0.333
Price	0.253	0.345	0.463
Distance	-0.261	0.131	0.046**
Repayment period	0.200	0.356	0.575
Access to credit	0.872	0.364	0.017**
Extension services	0.593	0.399	0.013**
Constant	-7.493	10.685	0.483

Pseudo R2 = 0.4509, Number of Observations = 150, LR chi2 (18) = 97.96,
Prob> chi2 = 0.0000, Log likelihood = -41.568975,
Asterisks ***, **, * represents significance levels at 1%, 5% and 10 % respectively

4.5.2 Distribution of propensity scores

To identify the existence of a common support, the distribution of propensity scores between farmers delivering to cooling plants (treated) and those that do not (control) groups was done using kernel density estimator. It has been argued that common support condition is a major source of bias in evaluating conventional approaches (Heckman *et al.*, 1997). Figure 3, depicts that there is a high chance of getting good matches and large number of matched sample size from the distribution since the propensity score distribution is skewed to the left for those delivering to cooling plants and to the right for those that do not.

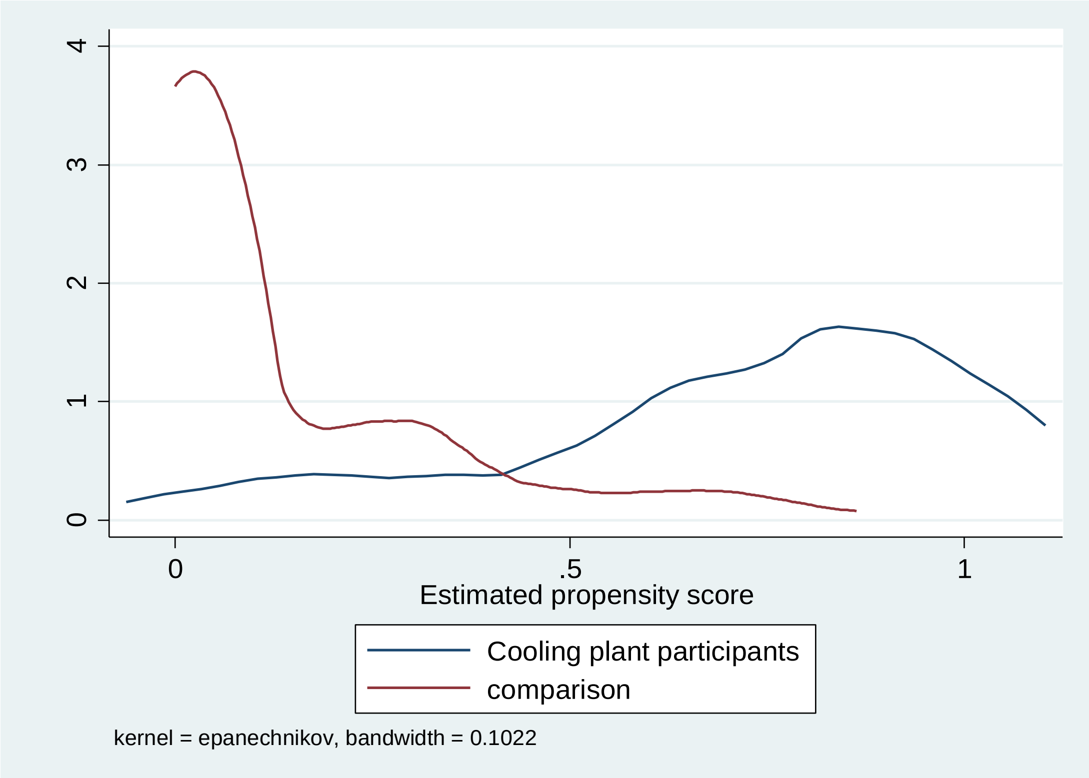

Figure 3: Propensity scores distribution among treatment and control groups

4.5.3 Choice of matching algorithm

Table 8 show the performance measure of matching algorithm estimators in the study area. Different matching algorithm estimators were tried in matching the treatment and control households in the common support region. Matching estimators were evaluated via matching dairy farmers delivering milk to cooling plant and those that do not in the common support region. Hence, based on the matching quality indicators, Nearest neighbor matching (NN6) which resulted in relatively low pseudo-R^2 with best balancing test (all explanatory variables are insignificant) and large matched sample size as compared to other alternative matching estimators was selected.

Table 8: Performance measure of matching algorithm estimators in the study area

	Performance Criteria		
Matching estimator	Balancing Test	Pseudo R^2	matched sample size
Nearest Neighbor matching			
NN(1)	15	0.399	45
NN(2)	15	0.228	45
NN(3)	17	0.177	45
NN(4)	17	0.166	45
NN(5)	17	0.148	45
NN(6)	17	0.145	45
Radius caliper			
(0.1)	17	0.631	45
(0.25)	17	0.197	45
(0.5)	16	0.151	45
Kernel matching (KM)			
Band width 0.6	15	0.178	45
Band width 0.1	15	0.178	45
Band width 0.25	15	0.178	45
Band width 0.5	15	0.178	45

4.5.4 Testing of covariates balance between treated and control groups

Table 9 report the balancing check of covariates comparing the matching algorithm significant differences using Nearest Neighbor matching algorithm. The balancing powers of the estimations between the matched and unmatched households selling milk to cooling plant were ascertained by considering different test methods such as; the reduction in the mean, standardized bias and equality of their means using t-test. In the nearest neighbor matching algorithm, the standardized bias difference before matching range between 18.1% and 92.5% in absolute values. T-values also showed that the chosen variables exhibited statistically significant differences before matching. After matching, the standardized bias differences for almost all covariates lied between 4.7% and 34.3% and all of the covariates were balanced (Table 9). This implies that sample differences in the unmatched data significantly exceeded those in the samples of matched cases. Hence, a high degree of covariate balance was created between the treatment and control samples.

Table 9: Testing of covariates balance using Nearest Neighbor matching for cooling plants users and non-users

		Mean		% reduction		T-test	
Variables	Sample	Treated	Control	%bias	bias	T	p>t
Gender(years)	Unmatched	1.4222	1.2843	28.9		1.65	0.102
	Matched	1.3571	1.4317	-15.6	46	-0.56	0.576
Age	Unmatched	31.8	36.98	-65.5		-3.23	0.002
	Matched	32.5	33.489	-12.5	80.9	-0.59	0.555
Marital status	Unmatched	1.3333	1.3627	-3.7		-0.21	0.836
	Matched	1.4286	1.3166	13.9	-280.7	0.54	0.593
Education level (years)	Unmatched	12.244	10.5	64.9		3.44	0.001
	Matched	11.821	11.695	4.7	92.8	0.21	0.836
Household size	Unmatched	4.8889	5.2157	-16.2		-0.89	0.377
	Matched	4.5357	4.8964	-17.8	-10.4	-0.66	0.515
Occupation	Unmatched	1.6222	1.7549	-28.7		-1.65	0.102
	Matched	1.6429	1.5493	20.2	29.5	0.7	0.484
Land size(ha)	Unmatched	4.5778	4.2373	14.6		0.77	0.443
	Matched	4.25	4.8089	-23.9	-64.1	-0.98	0.331
Off-farm income	Unmatched	10907	9597.1	12.1		0.67	0.504
	Matched	10929	12188	-11.6	3.8	-0.42	0.676
Experience	Unmatched	9.2667	8.1275	17.4		0.95	0.343
	Matched	8.3214	7.4528	13.3	23.8	0.61	0.546
Contract	Unmatched	1.0222	1.0784	-25.8		-1.31	0.193
	Matched	1.0357	1.0911	-25.4	1.5	-0.84	0.404
Group membership	Unmatched	0.64444	0.22549	92.5		5.32***	0.000
	Matched	0.53571	0.42583	24.2	73.8	0.81	0.42
Milk Volume	Unmatched	14.133	9.5294	62.8		3.92***	0.000
	Matched	11.286	12.035	-10.2	83.7	-0.42	0.673
Price	Unmatched	29.333	27.735	18.1		6.13***	0.000
	Matched	29.036	28.749	21.2	82	0.89	0.377
Distance to the market	Unmatched	1.9622	2.2485	-17.5		-0.93	0.354
	Matched	2.0179	1.9931	1.5	91.3	0.06	0.954
Repayment period	Unmatched	2.8667	2.6667	39.5		2.13**	0.035
	Matched	2.7857	2.8563	-13.9	64.7	-0.52	0.604
Access to credit	Unmatched	1.3333	1.6863	-74.8		-4.2***	0.000
	Matched	1.4286	1.4779	-10.5	86	-0.36	0.717
Extension service	Unmatched	1.3333	1.2843	10.5		0.59	0.553
	Matched	1.2857	1.4454	-34.3	-225.7	-1.24	0.222

((% reduction /bias= unmatched % bias – matched % bias) / unmatched % bias)* 100)).

, * represent significance level at 5% and 10% respectively.

4.5.5 Estimation of average treatment effect (ATT) on income

The effects of delivering milk to cooling plants as a market outlet on household income was computed based on the selected Nearest Neighbor Matching (NNM). However, Heckman *et al*. (1998) argued that for better results and understanding, more than one matching method can be used. Therefore, in addition to NNM, Stratification Matching (SM), Radius Matching (RM) and Kernel Based Matching (KBM) were used to measure the effects of delivering milk to cooling plants on household income.

The estimation results provide a supportive evidence of statistically significant effect of the cooling plant on household income in terms of KES. The results from the four matching approaches indicated a positive and significant effect on the level of household income. This suggests that cooling plants play an important role in the income status of smallholder dairy farmer. After controlling for pre-intervention differences in socio-economic, institutional and other characteristics of the treated and the control households, it was found that, on average, selling milk to cooling plants has increased income of the households by KES 16,680.00 per lactation period (Table 10). The amount was significantly higher than what was realized by their counterparts at 95% confidence level.

Table 10: Estimation average treatment effect (ATT) on income indicators (KES)

Matching methods	No.of Treated	No.of controls	ATT	Std. Err.	T
Nearness Neighbor Matching	45	15	16680.00**	26600.07	0.62
Stratification Matching	45	45	4596.07**	20454.33	0.22
Radius Matching	34	45	843.95*	11234.49	0.07
Kernel Matching	45	45	2814.89**	15805.91	0.17

Asterisks *, **, and *** represents significance levels at 10%, 5% and 1% respectively.

The empirical results based on SM, RM and KBM also shows that farmers selling to cooling plants received KES 4596.07, KES 843.95 and KES 2814.89, respectively more than those that do not (Table 10). This confirms that, the average household income for farmers delivering to cooling plants was more than those who do not, depending on the matching method used. The possible explanations for this increment in total income could be fairly high prices paid by cooling plants and reduction in costs of production and marketing for service users.

A number of coefficients for the interacted terms in the study were also found statistically significant, thus confirming the heterogeneity of the effects of delivering milk to cooling plants on household income. For instance, the coefficients for the interacted terms for education (0.14), extension service (0.59), gender (0.78) and group membership (0.82) were positive and statistically significant at 95% confident level. These indicate that the effect of selling to cooling plants on household was higher among households that were educated, received extension services and has membership in the cooling plant. However, the interacted terms like age, household size and distance was negative and statistically significant, suggesting that the effect of delivering to cooling plants on household income decreases with increase in the variables. The benefits of cooling plants can be witnessed through income increment among users.

Generally, cooling plants has income generating opportunities by supporting and encouraging surplus milk production and by providing information to its members. While income could be direct results of cooling plant, other benefits could be resulted from new opportunities created for both milk producers and the surrounding community in terms of employment due to the presence and functioning of cooling plants. This is because, cooling plants reduce milk spoilage and famers can also deliver their evening milk. In addition, cooling plants have the power to increase the producers bargaining power in the market places and permits dairy producers to combine their strength and gain more income**.**

4.5.6 Sensitivity analysis

Table 11 shows the results of Simulation based sensitivity analysis. Sensitivity analysis was conducted to ascertain the robustness of the estimates. Rosenbaum (2002) argued that, matching only balances the distribution of observed characteristics if there are unobserved variables that simultaneously affect assignment into treatment hence the outcome variable might lead to hidden bias. This study addresses this problem with the bounding approach suggested by Rosenbaum (2002). The goal of the approach was to determine how strongly an unmeasured variable must influence the selection process to undermine the implications of the matching process. The results of sensitivity analysis show that the estimated treatment effects were insensitive to hidden bias with gamma values ranging from 1.91 to 1.99 for the nearest neighbor matching, 1.61 to 1.72 for kernel based matching and 1.62 to 1.67 for the radius matching. A gamma level of 1.91 for instance, imply that if individuals with same X- vector differ in their odds of those selling milk to cooling plants by a factor of 91 percent, the positive significance of the cooling plant effect on income in Sotik Sub-County may be questionable. Additionally, the study revealed that, the simulated ATT of the outcome variable which is milk cooling plant income is very close to the baseline ATT.

This implies that, it is only when a confounder is simulated to provide implausibly large outcome effect. The study therefore concludes that the ATT estimates for household income are robust indicators of the effect of delivering milk to cooling plants.

Table 11: Results of Simulation Based Sensitivity Analysis

Matching algorithm	Baseline ATT	Simulated ATT	Gamma level (Γ)	t-stat
Nearness Neighbor Matching	16680.00	16157.20	1.91 - 1.99	2.01
Kernel Based Matching	4596.07	4502.45	1.61 - 1.72	2.32
Radius Matching	2814.89	2760.23	1.62 - 1.67	2.13

NB: Γ- refers to the outcome effect which measures the estimated effect of the simulated confounder on the relative probability to have a positive outcome in case of no treatment.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The results of this study affirmed that age, gender, education level, access to extension service, access to credit, milk price, household size and group membership significantly influence the decision to deliver milk through cooling plants. This means that, those households who are highly educated, near to the market outlet, have smaller family size, belongs to an existing group and are highly affected by price flexibility in the market are most likely to deliver their milk to cooling plants. Households that were headed by more educated heads were likely to sell through the cooling plants than their counterparts. Provision of education and extension services to the farmers on different milking marketing outlets is therefore a key to accessing the best marketing outlet. Consequently, choice decision of appropriate milk marketing outlet ensures high gross margins.

Gross margin results show that all the three marketing outlets were profitable in the study area. However, the gross margins varied among the outlets. Interestingly, dairy farmers delivering to cooling plants in Sotik sub-county had higher gross margin of KES 10.84 per litre compared to those of cooperatives and vendors/neighbors who received KES 8.15 and KES 7.27 per litre, respectively. The observed difference in milk returns was mainly attributed to the costs incurred in the different marketing outlets. Though most farmers are still selling to the traditional milk market outlets in spite of the growing cooling plants which are more profitable in the area, the gross margins that would accrue from their enterprise if they deliver milk to the cooling plants could still be considerably higher.

For the effect analysis, it was noted that delivering milk to cooling plant positively and significantly increase the income of dairy farmers. After matching the farmers delivering to cooling plant with those that do not on the basis of their propensity score, the gains from cooling plants was KES 16, 680 per lactation period more than their counterparts. Generally, the findings show that delivering milk direct to a cooling plant is economically viable and an important tool in increasing smallholder dairy farmers’ income.

5.2 Recommendations

The factors influencing the decision to deliver milk to cooling plants and its effects on household income were studied only in Sotik Sub-County. However, the situation may be different in other areas of the country. For generalization of the whole country, it is worth enough if a research considering the remaining part of the country is done. Additionally, future studies may be conducted to analyze the conditions for the emergence of cooling plants to understand why they appeared in some areas and not in others. It would also be appreciable in future studies to identify factors that lead farmers to join the cooling plant or not. Such studies would help to guide policy makers to facilitate the development of cooling plant and strengthen their effect on household income. To reduce milk losses and increase the income of the smallholder dairy farmers, the government and non-governmental organization should further expand the modern milk market outlets through the establishment of milk cooling centers since they are more rewarding. This study therefore, recommended policy interventions in increasing milk market awareness through creation of strategies that would improve socio-economic conditions of smallholder dairy farmers. This can be done by providing farmers with extension services on the importance of milk cooling plants so as to improve the knowledge of the farmers and increase their milk productivity which in turn will lead to increased household income

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APPENDIX 1: QUESTIONNAIRE

Dear respondent,

My name is ……………………………………..Am research assistant involved in the survey aimed at improving the dairy sector at farmer level. This is an important initiative which will be aimed at improving farmers` income through development of the best marketing outlets. You have been randomly selected as one of the farmers to participate in the survey. The information and subsequent findings will only be used for academic purpose and will be treated with at most confidentiality

Enumerators name	Farmers name	Location	Ward	Date

SECTION A: HOUSEHOLD INFORMATION

Please tick (√) the appropriate choice

1. Gender: 1) Male ☐ 0) Female ☐
2. How old are you in years? ☐
3. What is your marital Status? 1) Married☐ 2) Unmarried 3)Divorced☐ 4) widow☐
4. What is your highest level of education in years?☐
5. What is the size of your household? ☐
6. What is your main occupation? ....
7. What is your monthly household farm income from dairying? ....
8. What is your monthly household off farm income? ....

SECTION B: MILK PRODUCTION AND DELIVERY

9. Please provide information on the main assets you own and their costs

Type of Assets Owned	No of Units	Unit Price(KES)	Total (KES)
Land			
Land under dairy			
Structure and builds			
Cows			
Vehicle			
Bicycle			
Motorcycle			
Chuff cutter			
Milk equipment			
Wheel barrow			
Pangas and jembes			
Hand carts			
Sprayer			
Others specify			

10. How many years have you been in the dairy enterprise? ☐

11. What was the source of your initial capital for the establishment of your dairy enterprise?

1) Own saving ☐ 2) Family ☐ 3) Formal credit ☐ 4) Informal credit ☐ 5) (Specify) ………

12. How much did it cost for the Construction of the cow shed in KES……………..

13. How many dairy cattle do you currently keep? ☐

14. How many cows do you milk a day? ☐

15. What is the average amount of milk (in liters) per day in KES? ……………

16. Please provide information on the costs you incur in milk production

Farm expenditure	No. of units	Cost per unit (KES)	Total(KES)
Fodder			
Owned produced fodder			
Commercial feeds (dairy meal, mineral supplement, molasses			
Labor (daily wages/monthly wages)			
Family labor			
Veterinary services			
Water			
Artificial Insemination			
Deworming			
Tick control			
Transport			
Others specify			

SECTIONC: MILK DELIVERY INFORMATION

17. How many litres do you milk per day? ☐

18. Do you sell the milk? 1) Yes ☐ 2) No ☐

19. If Yes, Where do you sell your milk1) KCC ☐ 2) Brookside ☐ 3) Milk cooling plant☐

4) Neighbours ☐ 5) Milk vendors ☐ 6) others (specify)………..

20. Do you sell all the milk to above market outlet? 1)Yes ☐ 2) No ☐

21. What price is offered per litre to; 1) KCC ☐ 2) Brookside ☐ 3) Milk cooling plant ☐

4) Neighbours☐ 5) milk vendors ☐ 6) Others (specify)…………

22. What means of transport do you use in delivering your milk?

1) Head carrying Bicycle ☐ 2) Public transport ☐ 3) Own vehicle ☐

4) Hired vehicle ☐ 5) other (specify)………

23. What is the distance in Km from home to the milk marketing outlet? ☐

24. What is your unit of measure for selling milk? 1) Liter ☐ 2) others (Specify)

25. Do you have contractual form of payment with your supplier? 1) Yes ☐ 2) No ☐

26. If yes, what is the mode of payment? 1) Daily ☐ 2) weekly ☐ 3) Monthly ☐

27. Are you a member of any other milk marketing outlet? 1) Yes ☐ 2) No ☐

28. If yes, specify ………………………………..

29. What additional benefits do you get from the above marketing outlet?..

....

30. Are there any challenges in delivering your milk? 1) Yes ☐ 2) No ☐

If yes, name them

……………………………………………………………………………………………

………………………………………………………………………

31. Do you access loan or credit from the milk channel you deliver milk to? 1) Yes ☐ 2) No ☐

32. What is the distance to the cooling plant? _____________ Kms

33. Do you consider the following as the major milk delivery problem facing farmers?

a) Fluctuation in the quantity of milk obtained from cows1) Yes ☐ 2)No ☐
b) Distance of milk collection centers from my home 1)Yes ☐ 2)No ☐
c) Lack of getting adequate market 1)Yes ☐ 2) No ☐

d) Inadequacy of labor in the household to transport milk 1)Yes ☐ 2)No ☐

e) Spoilage of milk during transportation 1) Yes ☐ 2)No ☐

f) Unable to get market information 1)Yes ☐ 2)No ☐

g) Access to credits/loans 1)Yes ☐ 2) No ☐

h) Others (specify) ____

34. List what you consider to be the major problems constraining you in channeling your milk via milk cooling plants.

………………………………………………………………………………………

35. Suggest ways in which such problems can be addressed

…………………………………………………………………………………………………

………………………………………………………………………………………

THANKS FOR YOUR COOPERATION. YOUR DETAILS WILL BE TREATED WITH CONFIDENTIALITY