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Impact of Milk Marketing Channel Choice Decision on Income, Employment and Breeding Technologies among Dairy Farmer Households in Kericho County, Kenya

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Abstract

The study examined the impact of milk marketing channel choice decisions on dairy farmer household income, employment and breed technologies among dairy farmer households in Kericho County. Data was collected from 432 dairy farmer households using multistage cluster sampling technique. Both primary and secondary data were used in the analysis. Processing and analysis of survey data was carried out using STATA version 12. Multivariate probit and propensity score matching was used in data analyse. Propensity score matching was also used to account for selection bias. Matching results show that the average effect of the farmer household that sold milk to commercial buyers had higher probability of obtaining Kenya shillings 16.00 per day as compared to households that did not sell milk to commercial buyer. While selling through commercial milk buyers had significant positive effect on farmer welfare, majority of dairy farmers were hesitant to engage with them. Milk buyers value security in supply which comes from trusted relationships and contracts. Establishing such relationships is in the long-term interest of the dairy farmer. Therefore, to improve farmer welfare, group formation and partnership development should be strengthened, milk cooperative societies needs to be bolstered and an increased financial investment in livestock markets by national and county governments.

Keywords: Propensity score matching, Milk marketing channels, Dairy farmer households.

Contents

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1. Introduction

Output prices received by farmers significantly determine their welfare especially in rural areas where there is weak non-farm income which limits diversification of agricultural production amongst producers. While there is some debate about the actual and potential impacts of having a wide array of commercial milk buyers on broader welfare of the rural poor, case study evidence suggests that farmers are worst placed when faced with a privately owned or government-controlled monopsony (Sadler, 2006; Gorton 2007). The choice of a milk marketing channel depends on a number of aspects. These include availability of the markets, milk prices offered in the markets, distance to the milk market and the potential of the market to absorb the volume on sale (Paterson, 1997). However, there is relatively little evidence linking milk marketing channel choices to dairy farmer household income and employment outcomes in the study area. While the theoretical arguments in favor of marketing cooperatives are well known, in practice their performance in developing countries has been patchy (Glover, 1987). Erratic rent seeking government intervention may reinforce these problems. While case studies (Striewe, 1999; Cocks *et al.*, 2005; Gorton *et al.*, 2006) and aggregate market analysis identify these difficulties, there is an absence of cross-sectional data analysis on the impact of milk marketing channel choice decisions on income, employment and technology among dairy farmer households in Kericho County, Kenya. This study therefore, attempts to fill this gap by analyzing the impacts of the available commercial milk buying channels on dairy farmer households in Kericho County, Kenya. However, certain factors are beyond the scope of the dairy farmers in the study area. For example, weak rural infrastructure, land fragmentation and weak capital base. Therefore, most dairy farmers are constrained by high transaction costs due to the great distances to milk markets, lack of adequate access to finance, and in some cases social factors (Nkosi and Kirsten, 1994). Also, information about markets and market prices guide the farmer in making informed decisions (Nkosi and Kirsten, 1994). Making uninformed decisions may result in the farmer accessing the market when it is not profitable to do so. This is a common situation where livestock farmers approach saturated markets with the wrong price signals (Nkosi and Kirsten, 1994).

The study contributes to the literature by empirically examining the impacts of the milk marketing channel choice decisions on dairy farmer household income, employment and technology. The study used propensity score matching model to control for self-selection since the choice decision for a particular milk buying channel is not random, with the group of dairy farmers being systematically different. By considering the causal relationship between participation in selling milk to commercial milk buyers and dairy farmer household welfare, this paper seek to address counterfactual queries that could be important in forecasting the impacts of policy changes. The study analyzed independently both farmers selling under commercial channels and for those that sell to final consumers in order to assess their impacts on the choice decisions made by the dairy farmer.

2. Objectives

2.1. General Objective

The general objective of the study was to evaluate the impact of milk marketing channel choice decision on dairy farmer household's income, employment and technology adoption in Kericho County, Kenya.

2.2. Specific Objectives

The specific objective of the study was to estimate the impact of milk marketing channel choice on dairy farmer household's income, labor hours and breed technology in Kericho County.

2.3. Hypothesis

The study tested the following hypothesis:-

$H_{O1:}$ The milk marketing channel choice has no impact on dairy farmer household income, labour hours and breed technology in Kericho County.

3. Research Methodology

3.1. Research Design

This study used cross-sectional and correlational research designs. A cross-sectional survey of dairy farmer households was carried out in early 2015. The study estimated income, employment and technology functions, endogenously stratified for each of the marketing channel used.

3.2. Study Area

Primary data was collect from smallholder dairy farmer households in six sub counties of Kipkelion East, Kipkelion West, Kericho West, Kericho East, Sigowet/Soin and Bureti of Kericho County as shown in table 2.1.

Table-1. Smallholder Livestock Milk Producers and Cooperative Societies

Sub – County	Number of households	Number of Dairy Farmers	Dairy Cattle Population	Average Number of Dairy Cows /Farmer	Dairy Cooperative societies /companies	Dairy Self-help groups
Kipkelion East	27791	13,996	20666	5	2	1
Soin/Sigowet	20940	15,141	12808	2	1	2
Kericho west	31394	17,111	26007	2	1	0
Bureti	30977	28,304	11400	2	11	24
Kericho East	27700	8,150	10498.8	3	2	3
Kipkelion West	14615	11,725	18667	4	4	3
Kericho County	153417	94,427	100047	3	21	33

Source: Kericho County Development Profile, 2013

3.3. Target Population

The primary unit of analysis was the household with dairy cows with milk for marketing. The target population was restricted to the 94,427 smallholder livestock milk producers and marketers, divided proportionately amongst the six sub-counties of Kericho County as shown in Table 1. Given the objective of the study, the population of interest was defined as the primary milk producer household who sell cows' milk to another supply chain actor. Therefore, farmers without dairy cows, those who did not sell any of the milk produced or those who processed all the milk themselves were excluded from the study. With the given focus, these restrictions were justified, and it meant that the sample could not be directly compared to official data on the structure of milk production.

3.4. Sampling Procedure

A multistage cluster sampling procedure was used to get the total population and sample size of interest.To achieve the study objectives, the county was clustered into six sub-counties, namely, Kipkelion East, Kipkelion West, Kericho West, Kericho East, Sigowet/Soin and Bureti as shown in Table 2. These sub-counties formed the sample sites for the study and the mean of the results from all these sites constituted the results for the whole county.

Table-2. Sub-County Sampling Areas

Constituency	Sub-counties	Divisions	Area (Km^2)	Number of Locations	Number of Sub locations
Ainamoi	Kericho East	Ainamoi	239.9	11	24
Belgut	Kericho West	Kabianga and Belgut	337.4	12	27
Sigoewet/Soin	Sigowet	Soin and Sigowet	473.2	13	38
Kipkelion West	Kipkelion West	Kunyak, Chilchila, Kamasian and Kipkelion	333	16	35
Kipkelion East	Kipkelion East	Londiani, Sorget and Chepseon	774.4	14	32
Bureti	Bureti	Bureti, Roret and Cheborge	321.1	19	53

Source: County Commissioner's Annual Report, Kericho, 2013

To achieve representative sample size, the six sub-counties formed the first-stage cluster that had the target population. These six clusters were selected based on the fact that small scale dairy farming was dominant and practiced throughout the county. Furthermore, it reflected significant differences in structure of the dairy milk marketing industry in the county. Further, within the six sub-counties, second-stage cluster sample of wards and villages with high concentration of small scale dairy farmers was then selected for the study. Sample selection of dairy farmer households from the clustered wards was done using random sampling and effort was made to include statistically significant sub-samples of dairy milk producers representing different milk marketing channels and sizes for each of the sub counties. The sampled milk producing n^{th} smallholder farmer household was determined by the proportionate size sampling methodology (Anderson *et al.*, 2007).

$$N_0 = \frac{Z^2 pq}{e^2} \quad (1)$$

Where N_0 was the sample size, Z is the standard normal value of 1.96 significant at 5 percent confidence level, *e* is themargin of error (the sampling error or desired level of precision), *p* is the estimated population proportion of smallholder dairy farmers with characteristics of interest assumed at 70 percent (Table 3.3). Thus taking *p* at 70 percent gave a representative size with minimal error making q = 1-p, i.e. 1-0.7 = 0.3, Z = 1.96, and e = 0.04 for a good precision respectively.

$$N = \left(\frac{1.96^2 * 0.7 * 0.3}{0.04^2}\right) = 504 \text{ dairy farmer households.}$$

Finally, based on the above calculation, the sample units (number of dairy farmers households) were calculated proportionately based on the number of dairy farmer households in each sub county and as a proportion of the total dairy farmers in the county against the desired sample size of 504 as shown in Table 3.

Table-3. Proportionate Distributions of Dairy Farmer Households

Sub – County	Number of Households	Number of Dairy Farmers	Percent Dairy farmer Households	Total proportion
Kipkelion East	27,791	13,996	15	75
Soin/Sigowet	20,940	15,141	16	81
Kericho west	31,394	17,111	18	91
Bureti	30,977	28,304	30	150
Kericho East	27,700	8,150	8	44
Kipkelion West	14,615	11,725	12	63
Total Kericho County	153,417	94,427	100	504

Source: Author's Computation from County Data, 2016

Therefore, a random sample of 504 dairy farmer households was set for the whole county with the intention of sampling representative cross-section of small scale dairy farmer households selling raw milk to different marketing channels available at farm gate. After data entry and cleaning, a total of 432 households were finally used for data analysis (Table 4). Within the county, sampling was weighted to the six sub-counties that had significant dairy cow production. The results that were obtained were assumed valid for the whole County.

Table-4. Distribution of Sample Smallholder Dairy Households

Sub-county	Respondents	Percentage
Ainamoi	54	12.50
Bureti	122	28.24
Kericho West	70	16.20
Kipkelion East	50	11.57
Kipkelion West	61	14.12
Soin/Sigowet	75	17.36
Total	432	100.00

Source: Author's Computation from Survey Data, 2016.

3.5. Data Types and Sources

Both primary and secondary data were used in this study. Primary data were collected through a survey. A structured pre-tested questionnaire was used and administered by trained enumerators through direct interviews amongst selected dairy farmer households. Primary data was also collected through discussion and observations of the farmers' dairy farming activities. Seasonal observations were also used to correlate those dairy farmer households left out from the network with the secondary milk market in order to estimate their supply and price variations. This involved observing the natural behavior (nonverbal expression of feelings, determine who interacts with whom, how dairy farmers communicate with each other, and to check for how much time is spent on various activities) of the dairy farmer households in order to describe existing situations and to obtain information that was relevant to the goals of the study.

Secondary data was obtained mainly from various sources including economic surveys, economic journals, statistical abstracts, conference reviews, books, magazines, official government of Kenya reports and documents such as statistical abstracts and bulletins, national and district development plans, national and county development and strategic plans, and Kenya Dairy Board records and annual reports. Different documents of livestock production and marketing, regional level reports and consultants' reports as well as National Bureau of Statistics publications were reviewed to gather more relevant information. Desktop literature and internet were also used to access credible information from available and accessible documents, published and unpublished reports, books and agricultural journals. Farm records from a few dairy farmer households were also used to supplement secondary data sources.

Given the importance accorded to the involvement of smallholder milk producers in the various milk marketing channels in this study, data types encompassed representative sample of households representing various categories of households, types of marketing channels (commercial and non-commercial), and changing structure of dairy sector was adopted. In order to analyze the response of the smallholder milk producers, the study focused mainly on whether the dairy farmer household sold milk at farm gate to commercial milk marketing channels (Y_1) and if farmer household chose to sell also to final consumers (non-commercial channel) (Y_0) or otherwise. Commercial milk marketing channels in this study were taken to mean three major marketing channels: organized cooperative societies, organized private sector milk buyers, and traditional/unorganized milk buyers. For a given village, there were four types of farmers: (i) farmers who chose to supply milk to the organized cooperative societies, (ii) farmers who chose to sell milk to the organized private sector milk buyers, (iii) farmers who chose to supply milk to the traditional or unorganized milk buyers such as milk vendors, restaurants, or directly to consumers and contractors and (iv) farmers who supplied milk to multiple channels like milk cooperative societies self-help groups, traditional and private milk buyers.

The data collected included dairy farmers' socio-economic characteristics, actual milk production, milk market competitiveness and other related obligations with the milk buyers. The socio-economic data collected comprised the farmer's age, education level, household size, gender, and farm ownership, off farm income, access to credit, access to extension service, membership to milk cooperative society and access to other milk marketing channels. The farm production data collected comprised the size of land under dairy production, average volume of milk produced per year, amount of livestock inputs such as feeds, breeding methods, types of labor used, capital used, cost of inputs, and farm gate prices of livestock outputs.

Respondents were also expected to provide information regarding market competitiveness and an estimated total number of potential commercial buyers for their milk. This would capture the degree of switching power from one commercial buyer to the other that farmers have in marketing their milk.

The study also included data on whether the farmer sold total milk output on contract or on signing agreements or on spot cash sale as an independent variable. Farmers may sell their milk on signing agreements with milk buyers rather than via spot cash sales. Agreements with buyers provide a greater degree of certainty for buyers regarding the availability of supply, for which a buyer may pay a premium (Gow and Swinnen, 2001). To capture the trustworthiness of commercial milk buyers, a measure of trust on the commercial milk buyer by the dairy milk farmer was included. This attribute was analyzed by a proxy that identified the perception that the dairy milk farmer had in relation to their trust in the commercial milk buyer. Finally regarding milk marketing characteristics, a dummy variable was introduced that captured whether the farmer sells via milk cooling/chilling plants, milk sheds or milk bars or not. Time series data on farm gate milk prices received by farmers over a period of three years (2013, 2014 and 2015) was also collected from the farmers. This entailed the use of pairwise comparison of the six sub county mean milk prices (means that were significantly different from each other) for the three years using Tukey's HSD (honest significant difference) test.

3.6. Instruments of Data Collection

A structured questionnaire was used as an instrument for data collection. The questionnaire was designed to address the objectives of the study. The questionnaires were administered by trained enumerators. The enumerators were identified from among the people who were conversant with the sub county wards and villages in the county to aid in data collection. The enumerators were trained for two days and the training culminated in the pre-testing of the questionnaire on the third week of December, 2015. Pre-test of data collection tool on the four dairy farmer households was done in Kericho East and Bureti sub counties respectively. Observations were also used to correlate those left out from the sampled population with the secondary milk marketing channels in order to provide estimates of their milk supply and milk prices received.

3.7. Data Analysis and Diagnostics

STATA version 12 was used for data analysis. The collected primary data was collated, cleaned, coded and stored in excel worksheets and IBM- SPSS version 21 before they were transferred to STATA for analysis. Empirical analysis in this study consisted of two stages. In the first stage, multivariate probit model was used to estimate the factors which determined the milk marketing channel choice decision equation, specifically whether farmers sell only to a commercial milk buyer or sell also to final consumers of milk. Secondly, propensity score matching model was used to analyze the impact of farmers' marketing choices on gross dairy income, milk yield, labor hours, and on breed technology). Diagnostic tests were also conducted from the regression results of STATA output. To check on multicollinearity, the study used variance inflation factor (VIF) and contingency coefficient (CC) among discrete and continuous variables, respectively. All assumptions were tested and corrected accordingly using STATA.

3.8. Analytical Frameworks

3.8.1. Theoretical Framework

The farmer or producers behave like neoclassical firms who control the transformation of inputs into valuable outputs in order to maximize profits (Varian, 2000). The decision on whether or not to adopt a new technology is considered under the general framework of utility or profit maximization (Norris and Sandra, 1987; Pryanishnikov and Katarina, 2003). It is assumed that economic agents, including smallholder subsistence farmers, use certain livestock milk marketing systems only when the perceived utility or net benefit from using such a method is significantly greater than is the case without it. Again smallholder dairy farmers are assumed to be rational and they want to derive the highest utility from the choices they make; either to market their produce independently or under a certain milk marketing channel. They make their choices with respect to random utility theory, which states that a decision maker is guided by unobservable, observable and random characteristics when making a decision. Although utility is not directly observed, the actions of economic agents are observed through the choices they make. Suppose that Y_j and Y_k represent a household's utility for two milk marketing choices, which are denoted by U_j and U_k , respectively. The linear random utility model could then be specified as:

$$U_j = \beta X_i + \varepsilon_j \text{ and } U_k = \beta_k X_i + \varepsilon_k \quad (2)$$

Where; $\boldsymbol{U_j}$ and $\boldsymbol{U_k}$ are perceived utilities of using a certain milk marketing channel *j* and *k*, respectively. $\boldsymbol{X_i}$ is the vector of explanatory variables that determines and or influences the perceived desirability of the choice of the milk marketing channel, B_j and B_k are parameters to be estimated, and ε_j and ε_k are error terms assumed to be independently and identically distributed (Greene, 2003). Therefore, for the case of choice of a livestock milk marketing channel, if a household (dairy farmer) decides to use option *j* marketing channel, it follows that the perceived utility or benefit from option *j* marketing channel is greater than the utility from other options (say *k*) marketing channel depicted as follows:

$$U_{ij}(\beta_j^1 X_i + \varepsilon_j) > (U_{ik}(\beta_k^1 X_i + \varepsilon_k), \quad k \neq j \quad (3)$$

The probability that a dairy farmer will choose milk marketing channel *j* among the set of livestock milk marketing channels to market his milk instead of the *k* marketing channel could then be defined as

$$P(Y = 1 \mid X) = P(U_{ij} > U_{ij}) \quad (4)$$

Therefore, $P(\beta_j^1 X_i + \varepsilon_j - \beta_k^1 X_i - \varepsilon_k > 0 \mid X)$

Hence $P(\beta_j^1 X_i - \beta_k^1 X_i + \varepsilon_j - \varepsilon_k > 0 \mid X)$

$$P(X^* X_i + \varepsilon^* > 0 \mid X = F(\beta^* X_i) \quad (5)$$

Where; *P* is a probability function, U_{ij}, U_{ik},, and X_i are as defined above, $\varepsilon^* = \varepsilon_j - \varepsilon_k$is a random disturbance term, $\beta_j^* = (\beta_j^1 - \beta_k^1)$ is a vector of unknown parameters that can be interpreted as a net influence of the vector of independent variables influencing the decision to sell a commercial milk marketing channel, and $F(B^* X_i)$ is a cumulative distribution function of the error terms (ε^*) evaluated at $B^* X_i$. The exact distribution of *F* depends on the distribution of the random disturbance term, ε^*. Depending on the assumed distribution that the random disturbance term follows, several qualitative choice models can be estimated (Greene, 2003).

Propensity score matching which is used in this study's analysis requires no assumption about the functional form in specifying the relationship between outcomes and predictors of outcome, unlike the parametric methods mentioned above. However, the drawback of the approach is the Conditional Independence Assumption (CIA), which states that for a given set of covariates, participation is independent of potential outcomes (Smith and Todd, 2005). Further, Smith and Todd (2005) note that there may be systematic differences between the outcomes of participants and non-participants, even after conditioning on observables. Such differences may arise because of selection into treatment based on unmeasured characteristics. To address the selectivity bias problems associated with choice decision of a milk marketing channel, this study employed the matching techniques in assessing the impact of selling to a commercial milk marketing channel on average dairy farmer household's gross income, employment and dairy breeding technology uptake.

The propensity score matching approach addresses the problem of the limited distributional assumption of the errors, and more importantly allows for a decomposition of the treatment effect on outcomes (Heckman, 1999). Also the counterfactual framework could detect "two important sources of bias in the estimation of treatment effects.

These include the initial differences between the group selling to commercial milk market channels and those selling to final consumers in the absence of treatment, and the difference between the two groups in the potential effect of the treatment.

3.8.2. Empirical Modeling of Effects of Market Channel Choices on Income, Labor Hours and Technology

Farmer's milk marketing channel choice decisions in this study were hypothesized to have not significant impact on various technological and economic parameters, such as income, productivity; employment and technology (breed composition). Here, the study estimated income, employment and technology functions, again endogenously stratifying for each of the marketing channel used. Since the separation of producers by market channel introduces a bias derived from an endogenous stratification of market channels, this bias needed to be corrected. The regression equations were estimated for the group selling to commercial milk market channels and those who sell to final consumers. Therefore, the structural model that was adopted for the analysis was the propensity score matching model (PSM) as shown in equation 2.7 and as adopted from Heckman (1999).

$$Y_i = \beta X_i + \beta K_i + u_i \quad (6)$$

Where; Y_i is household income, employment or technology; X_i is a vector of the explanatory variables, representing personal and household characteristics and assets, and distance; K_i is the dummy variable representing one, if a dairy farmer sells to a commercial milk buyer and 0 for those selling also to final consumers; β are the coefficients and u_i is the error term.

The specification above in equation treats milk market choice decision by the dairy farmer household as an exogenous variable on the premise that households opts for a milk buyer to increase their income, employment of resources or to improve on their technological status. Nonetheless, this need not be the case, since better-off dairy farmer households may be better predisposed to several commercial milk markets as compared to the poor dairy farmer households. Furthermore, the decisions to choose or not to choose a particular milk marketing channel choice may be dependent on the benefits from the choice of the milk marketing channel. Thus, the choice of the milk marketing channel is not random, with the group of dairy farmers being systematically different. However, selection bias occurs if unobservable factors influence both the error term (u) of the choice equation, and the error term (ε) of the income equation, thus resulting in correlation of the error terms.

To evaluate the impact of various milk marketing channel choice decisions on smallholder dairy farmer's income, both farmers selling under commercial channels and for those not were expected to show the same observable characteristics. The study assumed that those selling through commercial milk marketing channels were taken as treatment and those not were taken as control. The average treatment effect (ATE) of involving commercial buyers is the difference between the actual income and the income for involving the commercial buyers in milk marketing, which is expressed as;

$$ATE = E(Y_{1i} - Y_{0i} / K_i = 1 \quad (7)$$

Where; Y_{1i} is the income when i^{th} farmer sells to commercial buyer, Y_{0i} is the income when the i^{th} farmer markets independently to final consumers and K_i is a dummy variable denoting the involvement of the commercial buyer, 1 = selling to commercial milk buyers, 0 = otherwise. The mean difference (D) between observable and control can be written as in equation 8 below.

$$D = E(Y_1 / K_i = 1) - E(Y_0 / K_i = 0) = ATE + \varepsilon \quad (8)$$

Where; ε is the bias. The estimated model used for the fourth hypothesis related to the impact on farmers' milk marketing choices, $Y_{1i,}$ (a binary variable which takes the value one if the farmer sells to commercial milk buyers only and zero if the farmer decides to sell also to final consumers), and their impacts on farmers' income, employment, and technology (Z_{ij}), is as specified in the equation below:

$$Z_{ij} = \beta_0 + \beta_{1,}AGE + \beta_2 EDC + \beta_3 ROAD + \beta_4 PART + \beta_5 \mathrm{PR} + \beta_6 VETFDS + \beta_7 HERD + \beta_8 EXP + \beta_9 LANDSIZE + \beta_9 FAMILYSIZE + \beta_{10} IMR + u_{ij} \quad (9)$$

$\boldsymbol{Z_{ij}}$ is a set of variables that were hypothesized to affect the farmer's marketing channel choices (Y_{1j}). These were the gross dairy income, milk yield, employment, and share of crossbred animals as dependent variables. Ideally, the dependent variable was the net dairy income. Regrettably, it was quite difficult to obtain accurate data on the value of some of dairy inputs. This was mainly true of dairy inputs for which livestock markets were not well developed, such as labor, home grown feeds and fodder, home-made feed ratios and in some cases costs data were missing completely.

A major reason why propensity score matching was employed was to address potential unobserved heterogeneity. As observed by Hujer *et al.* (2004) a possible hidden bias might occur if there are unobserved variables that tend to influence simultaneously commercial milk marketing channel choice decision and dairy farmer household income, employment and breed technology. Given that it is not possible to estimate the magnitude of selection bias with non-experimental data. Rosenbaum and Donald (1985) suggested the use of the bounding approach to examine the influence of unmeasured variables on the selection process. As a consequence, the study used gross dairy income per animal per household as the dependent variable in the second stage of the Heckman model. The Inverse Mills' Ratio was also be used to correct the error terms in the impact equations to achieve consistent and unbiased estimates.

3.9. Diagnostic Tests for Multinomial Logit

The study used variance inflation factor (VIF) and contingency coefficient (CC) among discrete and continuous variables, respectively. Potential multicollinearity among explanatory variables was tested and it was found not to have any potential influence on estimates from the model. The highest pair-wise correlation was 0.4 whereas multicollinearity is a serious problem if pair-wise correlation among regressors is in excess of 0.5 (Gujarati, 2004). An analysis of variance inflation factor did not show any problem since none of the VIF of a variable exceeded 8 (Greene, 2003).

4. Empirical Results and Discussion

Probit model was used to estimate the propensity scores. The scores were only used to balance the observed distribution of covariates across the treated group (farmers selling to commercial buyers) and the untreated group (farmers not selling to commercial buyers). The independent variables used in the probit regression model to predict the propensity scores were based on past research on determinants of participation in nonfarm employment (Barrett *et al.*, 2001) in Owusu *et al.* (2014).

From Table 5 results, most of the variables included in the estimation have the expected sign. In particular, participation in milk marketing and household size were found to be positively and significantly related to milk marketing. The coefficient for dairy farmer household participation in milk marketing was positive and significant. The presence of a milk buyer enhanced the probability of participation in the milk market. According to Kousar and Abdulai (2015) endowments with valuable household assets represents household's wealth and the presence of a development project in an area enhance the probability of participation for both male and female in non-farm earning activities.

The coefficient of household size was positive and significant balancing factor for propensity score matching. This suggests that the presence of labor availability in the household tend to increase the milk output levels which will then increase the probability of dairy farmer households selling their milk to commercial milk buyers. These results are in contrast to the study of Barrett *et al.* (2001) and in line with the study of Kousar and Abdulai (2015) in the case of male labor supply. The distribution of propensity of propensity scores before and after matching clearly indicate that estimating the *p*-score appears to balance the treated and untreated groups extremely well than without the *p*-score, a result which underscored the significance of the propensity score matching approach for this study.

Table-5. Probit Estimates of the Propensity Score for Dairy Farmer Household's Milk Marketing Involvement

Major farm gate milk buyers (Commercial or Final consumers)	Coefficient	Standard Error	Z	P>|z|
Age of household head	-0.0026244	0.0083386	-0.31	0.753
Education level	0.0103616	0.0597299	0.17	0.862
Distance to Milk Market	-0.0257749	0.0162404	-1.59	0.012**
Milk marketing participation	0.319914	0.1308435	2.45	0.014**
Price risk	-0.2414148	0.1867471	-1.29	0.006*
Veterinary feeds	0.0512779	0.1309099	0.39	0.695
Farming experience	0.0074178	0.0091395	0.81	0.017**
Total farm size	0.0105474	0.0100193	1.05	0.002*
Total household size	0.0484578	0.0275248	1.76	0.008*
Gross Income	0.005435	0.0022667	2.40	0.016**
Net Income	-0.0042365	0.0021526	-1.97	0.049**
Employment hour	0.003493	0.0031162	1.12	0.002*
Technology (Breeding)	-0.0014355	0.0018119	-0.79	0.028**
Constant	-0.1393711	0.454589	-0.31	0.759

Key:
Caliper = 0.001
Nearest Neighbour = 1
Number of observations = 432
LR chi^2 (13) = 25.97
Prob > chi^2 = 0.0172
Log likelihood = -284.59954
Pseudo R^2 = 0.0436
* Significant at 1 percent; ** significant at 5 percent; *** significant at 10 percent

Source: Author's Computation from Survey Data, 2016

Pseudo-R^2 from probit estimation indicated the goodness of fit of the model or how well the regressors explained the probability to sell to commercial buyers. From the table of results, after matching, pseudo- R^2 was fairly low (0.0436), which showed that the matching procedure balanced the determining factors (covariates) very well for this study.

4.1. The Mean Differences in Outcome Variables in the Matching Analyses

Table 6 compares the mean differences in the outcome variables and other household and farm-level variables between dairy farmer households selling milk to commercial buyers and dairy farmer group not selling milk to commercial buyers. Given that the mean difference comparisons do not account for the effect of other characteristics of farm households, they confound the impact on household gross income, employment and breed technology adoption (dairy breeding) status with the influence of other characteristics. The significance levels suggest that there are some differences between those who sell to commercial milk buyers and those not with respect to household and farm-level characteristics. With regard to the outcome variables, there were statistically significant differences in household income and employment hours between the two categories of dairy farmers. Therefore, we again rejected the null hypothesis that the milk marketing channel choice has no impact on dairy farmer household income, labour hours and breed technology in Kericho County.

Table-6. Propensity Score (Pscore) Matching Analysis

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Net Income	Unmatched	172.252586	148.97167	23.2809153	12.3018885	1.89
	ATT	172.450649	154.408731	18.0419177	17.2355653	1.05
	ATU	148.849432	162.68549	13.8360576	.	.
	ATE			16.1310585	.	.
Gross Income	Unmatched	206.621994	190.094018	16.5279754	12.8656873	1.28
	ATT	207.007684	188.762198	18.2454867	18.3727788	0.99
	ATU	189.250915	193.497668	4.24675287	.	.
	ATE			11.8854063	.	.
Employment hours	Unmatched	10.8287367	9.75894024	1.06979644	2.48402087	0.43
	ATT	10.925244	6.45855443	4.46668959	2.76165675	1.62
	ATU	9.85423381	8.3365533	-1.51768051	.	.
	ATE			1.74779545	.	.
Technology	Unmatched	55.0968127	58.0400175	-2.94320479	3.50114827	-0.84
	ATT	55.3412638	56.0343963	-0.693132423	5.2095683	-0.13
	ATU	58.5095023	60.2395584	1.73005617	.	.
	ATE			0.407801035	.	.

Note: Standard error does not take into account that the propensity score is estimated.
Source: Author's Computation from Survey Data, 2016

Results in Table 6 further shows that the means of the treated group (farmers selling to commercial buyers) and the control group (farmers not selling to commercial buyers) are different. The magnitudes of the coefficients of the treatment effects indicate that the average treatment effects for the treated (ATT) are higher than the average treatment effects for the entire sample (ATE) and the average treatment effects for the untreated (ATU) except for technology outcome variable.

The matching estimates generally indicated that selling to commercial milk buyers exerted positive, significant and unbiased impacts on household gross income and hence net income (Table 6). These ATT effects demonstrate that dairy farmer households who sell milk through these commercial milk buyers increase their gross income thereby improving their welfare over and above those that are less motivated to commercial milk buying channels. After matching, dairy farmer households selling to commercial milk buyers raised their daily net income in the household by 18.00 Kenya shillings on average per dairy cow. According to Owusu and A. (2009) households that have a higher probability of participating in non-farm work are able to obtain higher incomes and improve their food security status over and above those that are less inclined to participate in non-farm work. This is in convergence with the current study findings. The matching estimates of the ATU effect indicates that if farmer households who did not sell their milk to commercial milk buyers had actually sold the milk (counterfactual condition), then their household income and employment hours would be on average higher than that of those who did sell their milk to commercial milk buyers.Owusu and A. (2009) further notes that the implication of such an outcome is that income and food security gains from participation in non-farm employment are slightly higher for households with a higher probability of participating than households with slightly lower chances of participating in non-farm employment.

Results further revealed that the matching estimates for gross income per animal on the treatment group, while balancing for the original level of gross income before and after treatment, also increased by 18.24 Kenya shillings (the nearest neighbour estimate of the average gain) after matching. Similarly, employment hours increased on average by 4 hour 46 minutes for dairy farmer households in the treatment group (those selling to commercial buyers) after matching results of the unobserved. This confirm earlier findings by Heshmati (2007) that the underlying technologies employed defines a production function to estimate the mean output rather than the maximum output.

After matching, the percentage of cows bred using modern breeding technologies for example AI or sexed semen decreased for the dairy farmer households in the treatment group (dairy farmer households selling milk to commercial buyers) by about 69 percent. This can be attributed to the high cost of dairy cow breeding in the study area that has been brought about by asymmetric information flow. Of particular concern have been breeding (A.I) prices that do not fully reflect quality because dairy farmers and breeders do not have the same information. This result is in convergence and in conformity with earlier studies by Eggertson (1990) who argues that before making a decision about how to market a product and to whom to sell it, producers must determine the price that they expect to receive. Further, Eggertson (1990) argues that transaction costs arise when market information is asymmetric as this induces activities such as information searchers, bargaining, market contracting, monitoring, enforcement and protection of property rights, which are, by nature costly.

The magnitude of the coefficients of the treatment effects indicated that the average treatment effects for the treated (ATT) were higher than the average treatment effects for the entire sample (ATE) and the average treatment effects for the untreated (ATU) for the outcome variables except for technology (Table 6). These results indicated that farmers who sold milk to commercial buyers had a higher probability of obtaining higher gross income per animal and had a higher probability of improving their welfare over and above those farmers who did not. The average effect of the treatment (ATE) for a dairy farmer household drawn from the overall population at random was Kenya shillings 16.00 higher because of selling to commercial milk buyers. This was because a positive effect was estimated for the dairy farmer households not selling to commercial buyers (ATU). The ATU effect by caliper matching estimates indicated that if farmer households that did not sell milk to commercial milk buyers had actually sold the milk, a counterfactual condition, then their household income and employment hours would be on average lower than that of those who did sell their milk to commercial milk buyers. The implication here is that the net income and employment hour gains from selling to commercial milk buyers are slightly higher for dairy farmer households with a higher probability of selling to commercial milk buyers than to dairy farmer households with slightly lower chances of selling to commercial milk marketing channel.

In performing PSM using the common option imposes a common support by dropping treatment observations whose pscore is higher than the maximum or less than the minimum pscore of the controls (Table 7). According to the results, five observations were dropped from the entire observations. Three from the treated group (farmers selling to commercial buyers) and two from the untreated group (farmers not selling to commercial buyers), respectively.

Table-7. Becker and Ichino (Psmatch2) PSM Estimation

psmatch2	**psmatch2**		
Treatment assignment	Common support		
	Off support	On support	Total
Untreated	2	194	196
Treated	3	233	236
Total	5	427	432

Source: Author's Computation from Survey Data, 2016

4.2. Matching Success for Impact/Outcome Factors

Table 8 give result of t-test on the hypothesis that the mean value of each of the outcome variables; namely age, education level, distance to the milk market, milk market participation, price risk, livestock feeds, farming experience, total farm size, household size, gross and net household income, employment hours and breed technology adoption was the same for the treatment group (farmers selling to commercial buyers) and non-treatment group (farmers not selling to commercial buyers). It was done both before and after matching. Pstest was used to check for the success of the matching for the outcome variables. Further, a bias before and after matching was calculated for each of the variables and the change in the bias stated.

Table-8. Indicators of Matching Quality before and after Matching (PSM Results)

Major farm gate milk buyers Commercial or Final								
	Unmatched	**Mean**		**%reduction**		**t-test**		**V(T)/V(C)**
Outcome Variables	Matched	Treated	Control	%bias	|bias|	T	p>|t|	
Age of household head	U	48.75	47.995	6.5		0.67	0.504	0.95
	M	48.639	51.12	-21.2	-228.5	-2.25	0.025*	0.89
Education level	U	3.0932	3.0561	3.5		0.36	0.717	0.91
	M	3.0944	3.0215	6.9	-96.7	0.74	0.460	0.88
Distance to Milk Market	U	3.0275	3.4564	-10.9		-1.13	0.259	1.08
	M	3.0399	3.378	-8.6	21.2	-0.93	0.352	1.10
Milk marketing participation	U	0.4661	0.3520	23.3		2.41	0.017	1.09
	M	0.4592	0.4506	1.8	92.5	0.19	0.853	1.00
Price risk	U	0.8517	0.8725	-6.0		-0.62	0.536	1.13
	M	0.8498	0.8584	-2.5	58.6	-0.26	0.794	1.05
Veterinary feeds	U	0.6568	0.6327	5.0		0.52	0.603	0.97
	M	0.6567	0.7082	-10.7	-113.5	-1.19	0.233	1.09
Farming experience	U	19.127	18.041	10.3		1.06	0.290	1.09
	M	19.03	21.485	-23.2	-126.0	-2.45	0.015*	0.99
Total farm size	U	5.4667	4.4128	15.8		1.61	0.109	1.90*
	M	4.885	4.4895	5.9	62.5	0.90	0.369	2.64*
Total household size	U	6.4025	5.9745	18.8		1.95	0.052	0.88
	M	6.382	6.4034	-0.9	95.0	-0.10	0.923	0.74*
Gross Income	U	172.25	148.97	18.5		1.89	0.059	1.66*
	M	172.45	148.45	19.1	-3.1	2.09	0.037*	1.87*
Net Income	U	206.62	190.09	12.5		1.28	0.200	1.56*
	M	207.01	182.98	18.2	-45.4	1.99	0.048*	1.68*
Employment hours	U	10.829	9.7589	4.3		0.43	0.667	3.81*
	M	10.925	6.7606	16.6	-289.3	1.83	0.048*	5.00*
Technology (Breeding)	U	55.097	58.04	-18.1		-0.84	0.401	0.89
	M	55.341	53.947	3.8	52.6	0.42	0.672	0.98

Source: Author's Computation from Survey Data, 2016

The bias before and after matching was calculated for each variable. This bias was the difference between the mean values of the treatment group and the control group, divided by the square root of the average sample variance in the treatment group and the not matched control group. Table 8 shows the differences in the values of the exogenous variables between the two groups before and after matching. For example, 46.61% and 35.2% of the treatment and control group respectively participated in milk marketing. This means that the results have significant influence on the treatment probability. The indicators of matching quality presented in Table 9 show substantial reduction in absolute bias for all the outcome variables for both the treated and non-treated. As indicated in the table (column 5), the mean bias in the covariates *Z* after matching lies below the 20 % level of bias reduction suggested by Rosenbaum and Donald (1985). This indicates that the covariates were significantly balanced as a result of the propensity score procedure.

Table-9. Indicators of Matching Quality before Matching and After Matching

Sample	Ps R^2	LR Chi^2	p>chi^2	Mean Bias	Med Bias	B	R	% Var
Unmatched	0.044	25.97	0.017	11.0	10.3	49.3*	1.01	31
Matched	0.032	20.77	0.078	10.7	8.6	40.5*	1.86	38

* If variance ratio outside [0.77; 1.29] for Unmatched and [0.77; 1.29] for Matched
Ps R^2 – Pseudo R^2, LR Chi^2 – Chi square likelihood ratio
Note:* *p*-value of Likelihood Ratio Test ($Pr > \chi^2$)
Note: Pseudo-R^2 from probit estimation indicates the goodness of fit or how well the regressors explain the probability to participate in an employment activity.

Source: Author's Computation from Survey Data, 2016

The pseudo-R^2 from the propensity score estimation and from re-estimation of the propensity score matching on the matched samples for both the groups was 0.044 and 0.032, respectively (table 3.5). However, if p>0.05, the null hypothesis could not be rejected on the 5% significance level. Therefore, the joint significance of the regressors on the treatment status could not be rejected after matching. It was, however, not rejected before matching either. The null hypothesis that the mean values of the two groups do not differ after matching cannot be rejected for the variables except for age, farming experience, and gross income. Therefore, it is possible to generate a control group, which is similar enough to the treatment group to be used for the ATT estimation.

The relatively low pseudo- R^2 after matching and the *p*-values of the likelihood-ratio test of the joint significance of the regressors imply that there is no systematic difference in the distribution of covariates between treatment and non-treatment groups after matching, suggesting that the overall results from the matching procedure are satisfactory in balancing the covariates between the treatment and non-treatment (Caliendo *et al.*, 2005).

4.3. Distribution of the Propensity Scores for Treated and Untreated Groups

Figure 1 gives the histograms of estimated propensity scores for the treated and non-treated groups of dairy farmer households. It shows the distribution and overlap (regions of common support) conditions of the propensity scores after matching for the two groups of dairy farmers (nearest neighbours).Visual inspection of the results reveals that the densities of the mean propensity scores are similar after matching and there is a clear overlap of the distributions. Propensity scores before and after matching as shown clearly indicate that estimating the *p*-score appears to balance the treated and untreated groups extremely well than without the *p*-score, a result which underscored the significance of the propensity score matching approach for this study. There is a clear balance between the two coordinates as they moved towards a central and a common area.

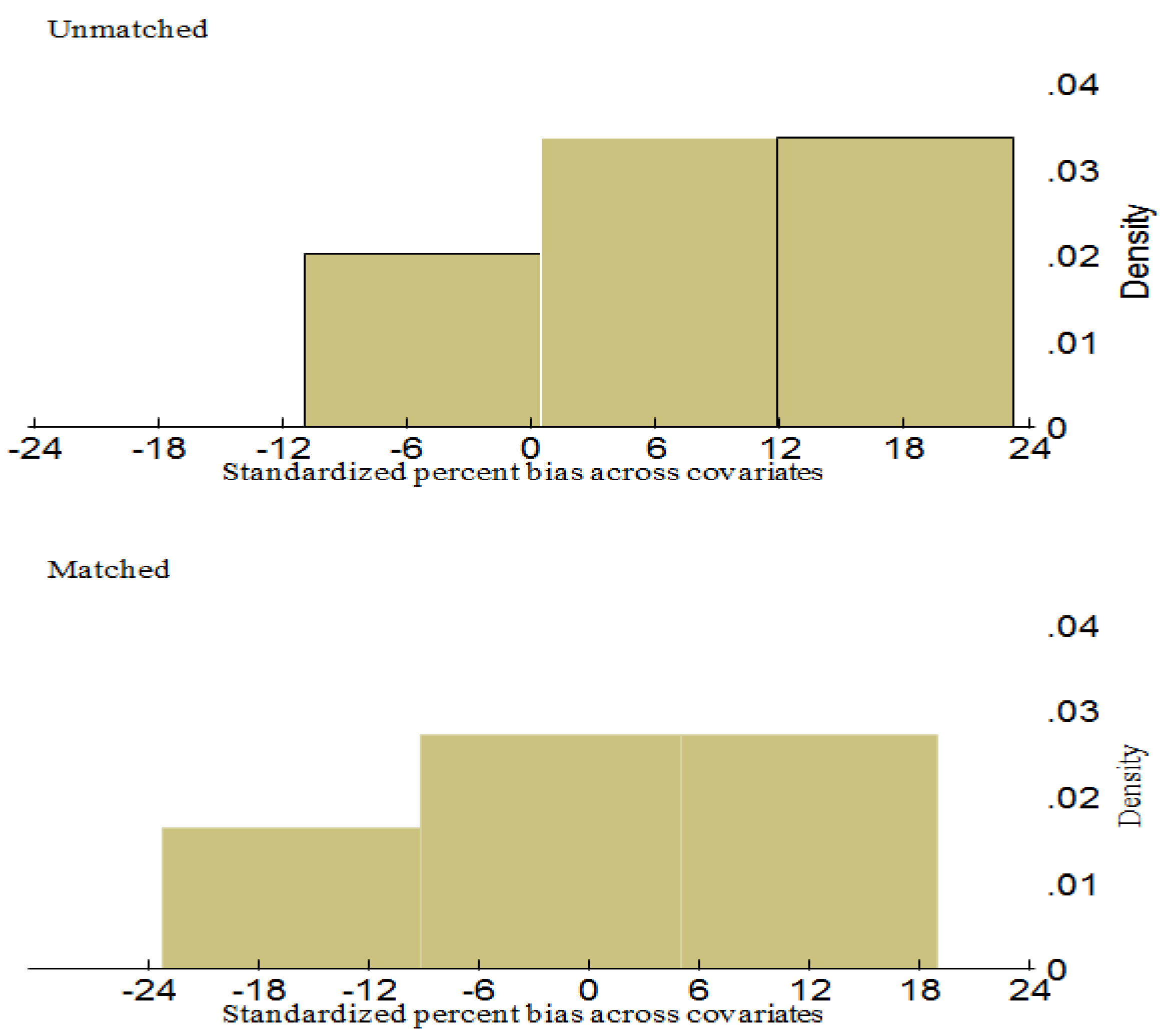

Figure-1. Density Distribution (Covariate Balance) of the Estimated Propensity Scores

Source: Author's Computation from Survey Data, 2016

4.4. Summary and Conclusions

This study examined the impacts of milk marketing channel choice decisions on dairy farmer household income, employment and breed technologies, using a cross-sectional sample of 432 dairy farmer households from six sub counties in Kericho County, Kenya. A propensity score matching model was employed to account for selection bias that normally occurs when unobservable factors influence both participation and non-participation in dairy milk marketing on the outcomes. The paper addressed dairy farmer heterogeneity by explicitly providing separate estimates for treated group (farmers selling to commercial buyers) and the untreated group (farmers not selling to commercial buyers). Results of the propensity score matching showed that the magnitudes of the coefficients of the average treatment effects for the treated (ATT) were higher than the average treatment effects for the entire sample (ATE), and the average treatment effects for the untreated (ATU) for the outcome variables except for breeding technology. The results indicated that farmers that sold milk to commercial milk buyers had a higher probability of obtaining higher gross income per animal per day and could improve their welfare over and above those farmers who did not. The average effect of the treatment (ATE) for a dairy farmer household drawn from the overall population at random was Kenya shillings 25.60 higher because of selling to commercial milk buyers.

The ATU effect by caliper matching estimates revealed that if a farmer household who did not sell milk to commercial milk buyers had actually sold the milk, their household income and employment hours would be on average lower than that of those who did sell their milk to commercial milk buyers. The implication here is that the net income and employment hour gains from selling to commercial milk buyers are slightly higher for dairy farmer households with a higher probability of selling to commercial milk buyers than to dairy farmer households with slightly lower chances of selling to commercial milk marketing channel. The growing interest of policy makers in promoting dairy milk production, particularly in the rural areas of Kenya is in the right direction as revealed by the results of this study. Besides being a valuable source of income for rural dairy farmer households in developing countries, dairy production also helps in smoothing household incomes, which in turn smoothens consumption hence improving farmer household welfare over long periods of time.

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