

**TECHNICAL EFFICIENCY IN COW MILK PRODUCTION: THE
CASE OF SULULTA DISTRICT, OROMIA SPECIAL ZONE
SURROUNDING FINFINNE, ETHIOPIA**

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**Technical Efficiency in Cow Milk Production: The Case of Sululta
District, Oromia Special Zone Surrounding Finfinne, Ethiopia**

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ECONOMICS)**

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DEDICATION

I dedicate this Thesis manuscript to the whole members of my family especially to my mother Chali Bedada.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this Thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this Thesis. Any scholarly matter that is included in the Thesis has been given recognition through citation.

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BIOGRAPHICAL SKETCH

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LIST OF ACRONYMS AND ABBREVIATIONS

AE	Allocative Efficiency
AI	Artificial Insemination
CSA	Central Statistics Agency of Ethiopia
DEA	Data Envelopment Analysis
GDP	Gross Domestic Product
EE	Economic Efficiency
KAs	Kebele Administrations
MD	Man Days
MLE	Maximum Likelihood Estimate
MOARD	Ministry of Agriculture and Rural Development
PPS	Probability Proportional to Size
SDAO	Sululta District Agricultural Office
SFA	Stochastic Frontier Approach
SNV	Netherlands Development Organization
SPF	Stochastic Production Frontier
TE	Technical Efficiency
TLU	Tropical Livestock Unit

TABLE OF CONTENTS

Contents	page
STATEMENT OF THE AUTHOR	iv
BIOGRAPHICAL SKETCH	v
ACKNOWLEDGEMENTS	vi
LIST OF ACRONYMS AND ABBREVIATIONS	vii
LIST OF TABLES	ix
LIST OF FIGURES	xi
LIST OF TABLES IN THE APPENDIX	xii
ABSTRACT	xiii
1. INTRODUCTION	1
1.1. Background of the Study	1
1.2. Statement of the Problem	3
1.3. Objectives of the Study	4
1.4. Significance of the Study	5
1.5. Scope and Limitations of the Study	5
1.6. Organization of the Thesis	6
2. LITERATURE REVIEW	7
2.1. Concept of Efficiency and Productivity	7
2.2. Theoretical Framework	8
2.3. Approaches of Measuring Efficiency	9
2.3.1. Input Oriented Measure	9
2.3.2. Output Oriented Measure	10
2.4. Models of Efficiency Measurements	11
2.4.1. Non-parametric Frontier Models	12
2.4.2. Parametric Frontier Models	12
2.4.2.1. The deterministic model	12
2.4.2.2. Stochastic frontier model	13
2.5. Estimation Stages of Determinants of Technical Efficiency	15
2.6. Empirical Studies on Technical Efficiency	16
2.7. Conceptual Framework	19
3. RESEARCH METHODOLOGY	21

Continuous

3.1. Description of the Study Area	21
3.2. Source of Data and Methods of Data Collection	22
3.3. Sampling Technique and Sample Size determination	23
3.4. Methods of Data Analysis	24
3.4.1. Descriptive Analysis	24
3.4.2. Econometric Analysis	24
3.5. Definition and Measurement of Variables with Hypothesis	28
3.5.1. Production Variables	28
3.5.2. Efficiency or Inefficiency Variables	29
4. RESULT AND DISCUSSION	35
4.1. Descriptive Statistics Results	35
4.1.1. Demographic Factors of Sample Households	35
4.1.2. Resource Basis	35
4.1.3. Institutional Factors	37
4.1.4. Milk Production	37
4.1.5. Constraints of Milk Production	38
4.1.6. Variables Used to Estimate the Production Function	39
4.1.7. Variables Used to Estimate Efficiency or the Inefficiency effect Model	41
4.2. Econometric Results	42
4.2.1. Hypotheses Testing	43
4.2.2. Parameter Estimates of the SPF Model	44
4.2.3. Technical Efficiency Scores	46
4.2.4. Sources of Technical Inefficiency in Milk Production	47
5. SUMMARY, CONCLUSION AND RECOMMENDATIONS	53
5.1. Summary and Conclusions	53
5.2. Recommendations	54
6. REFERENCES	57
7. APPENDICES	64

LIST OF TABLES

Table	Page
1. Sample distribution in selected four kebeles	24
2. Definition of explanatory variables and their expected effects	34
3. Major problems of milk production in the study area	39
4. Descriptive statistics of both input and output variables	40
5. Variables used in the efficiency model analysis	411
6. Generalized likelihood ratio tests of hypothesis for the parameters of the SPF	43
7. Maximum-likelihood estimates of the cobb-douglas spf with inefficiency model	45
8. Estimates of technical efficiency scores of the sample households	47
9. Maximum likelihood estimates of the factors determining technical efficiency	48
10. Age of households and mean level of technical efficiency	49

LIST OF FIGURES

Figure	Page
1. Measure of technical efficiency	10
2. Output oriented measures for technical efficiency	11
3. Conceptual framework for efficiency analysis	20
4. Map of oromia national regional state and the study area	22

LIST OF TABLES IN THE APPENDIX

Appendix Tables	Page
1. Conversion factor to calculate man equivalent	65
2. Conversion factor used to estimate tropical livestock unit equivalents	65
3. Estimated level of household's technical efficiency	66

Technical Efficiency in Cow Milk Production: The Case of Sululta District, Oromia Special Zone Surrounding Finfinne, Ethiopia

ABSTRACT

The present study was undertaken in Sululta district, Oromia Special Zone Surrounding Finfinne, Ethiopia with the objectives of analyzing technical efficiency in cow milk production and identifying factors that determine technical efficiency. Cross sectional data from randomly selected sample of 130 milk producing households were collected to obtain data pertaining to milk production, input usage, and other variables including natural, socioeconomic and institutional factors during 2015/16 production year. Multi-stage stratified random sampling technique is implemented to draw representative samples. Four kebeles were selected randomly and sampling frame has been constructed on the basis of a list provided by the district agricultural office. The estimated results of the Cobb-Douglas frontier model with inefficiency variables show that the mean technical efficiency of the farmers in the production of cow milk is 74%. This implies a sizeable inefficiency in milk production. The discrepancy ratio gamma (γ), which measures the relative deviation of output from the frontier level due to inefficiency, was about 91%. This implies that about 91% of the variation in milk production among the sample farmers was attributed to technical inefficiency effects. The result revealed that milk output was positively and significantly influenced by the number of cows, labor man-day, quantity of concentrate and dry fodder. The positive coefficients of these parameters indicate that increased use of these inputs will increase the production level to a greater extent. Hence, given these inputs are used to their maximum potential, introduction and dissemination of these inputs will enhance the production level of milk in the area. The estimated stochastic production frontier model together with the inefficiency parameters show that, age, total livestock holding, availability of grazing land, breed type, distance to market center and frequency of extension contact negatively and significantly affected technical inefficiency of milk production implying that improvement in these variables may improve technical efficiency. However, age-square and land ownership of households positively and significantly affected technical inefficiency of milk production showing that these variables have negative influence on technical efficiency. Hence, emphasis should be given to improve the efficiency level of those less efficient households by adopting the practices of relatively efficient households. In conclusion, policies and strategies of the area should be directed towards the improvement of the above mentioned determinants.

Key words: Stochastic production frontier, technical efficiency, cow milk production.

1. INTRODUCTION

1.1. Background of the Study

Agriculture is the main economic pillar of the Ethiopian economy and the overall economic growth of the country is highly dependent on the success of the agriculture sector. The sector represents 42% of the GDP of the country and about 85% of the population gain their livelihood directly or indirectly from agricultural production (CSA, 2015). Within agriculture, 50% of the output of the agricultural GDP comes from crop production, whereas 47% and 3% comes from livestock and forestry, respectively (Fitawok and Roy, 2012). Ethiopia is naturally endowed with different agro ecological zones and suitable environmental conditions that used as a home for many livestock species and suitable for livestock productions (CSA, 2013, and Helina and Schmidt, 2012).

According to (CSA, 2015) livestock survey made, the country is reported to be endowed with the largest livestock population in Africa and the cattle population was estimated at about 56.71 million. The indigenous breeds accounted for 98.66%, while the hybrids and pure exotic breeds were represented by 1.19 and 0.14%, respectively. From the total cattle population, 45.55% are males and 55.45% are females. On the other hand, the majority of the cattle population (that is about 63.52%) are in three years age category and those with age category of 10 years and over took 2.07% of the total estimated number of cattle population. There are 700168 local and 61079 crossbred cows in north Shewa zone. The survey results also showed that the dairy cows and milking cows are 166307 and 287992 respectively and average daily milk production per cow is 1.66 (CSA, 2015).

The livestock subsector has an enormous contribution to Ethiopia's national economy and livelihoods of many Ethiopians, and still promising to rally round the economic development of the country by generating income to farmers, creating job opportunities, ensuring food security, providing services, contributing to asset, social, cultural values, and sustain livelihoods. The subsector contributes about 16.5% of the national Gross Domestic Product (GDP) and 35.6% of the agricultural GDP (Fitawok *et al.*, 2011).

Dairy production is becoming an increasingly important integrated system in many countries, in which this component generates significant, and more importantly, daily cash

income, as well as contributing to the improvement of the livelihoods of very poor people and the stability of farm households. It is for these reasons that dairying is considered to be an important instrument of social and economic change (Mumba, 2012).

According to Azage *et al.* (2013), Ethiopia has a huge potential for dairy development in Africa. The large and diverse livestock genetic resources, existence of diverse agro-ecologies suitable for dairy production, increasing domestic demand for milk and milk products, better market opportunity, and proximity to Europeans international markets indicate the potential and opportunities for dairy development in the country.

Tesfaye *et al.* (2010) argued that, given the challenges facing the dairy subsector in Ethiopia, government policy has a critical role in facilitating transformation of the prevailing smallholder dairy production systems to productive, sustainable, market-oriented dynamic systems. This is because livestock have diverse functions in the livelihood of farmers in the mixed crop–livestock systems in the highlands and pastoralists and agro-pastoralists in the lowlands of Ethiopia. Akin, it is not difficult to find out what livestock provide to farmers in the form of meat and milk, and non-food items such as, manure and transport services as inputs into food crop production and fuel for cooking. They are a source of income, which can be used by rural populations to purchase basic household needs and agricultural inputs.

Though Ethiopia is known by the largest cattle population on the continent, the country is not among the four largest milk producing countries like Egypt, Kenya, South Africa and Sudan in Africa (Zelalem *et al.*, 2011). Milk and milk product play a very important role in feeding the rural and urban population of Ethiopia and have a high nutrition value and is daily produced, sold for cash or readily processed (Anteneh *et al.*, 2010).

Thus, the current study analyzes technical efficiency of smallholder milk producers in Sululta district, Oromia Special Zone Surrounding Finfinne, Ethiopia, where milk is the major product produced from dairy cows. Even though animal product especially, milk is the most predominant product in Sululta district in which this study was carried-out, there is no empirical study that showed whether the existing scarce resources and technologies are utilized efficiently or not in the milk production. Therefore, this study made an attempt

to measure the technical efficiency of milk producers and identifies its determinant factors in the study area.

1.2. Statement of the Problem

If the existing production system is not efficient, introduction of new technology could not bring the expected improvements in the productivity of milk and other dairy products . Given the existing technology, improvements in the technical efficiency will enable farmers to produce the maximum possible output from a given level of inputs. Hence improvement in the level of technical efficiency will increase milk production (Ajabush, 2016).

Given the case that developing countries have scarce resources to undertake new investments on modern agricultural technologies, improving the technical efficiency of farmers is indispensable i.e. there is a wide room for increasing agricultural productivity and production in these areas by improving technical efficiency of farmers at the existing resources (Asefa, 2016). Efficiency analysis in milk production becomes important in underdeveloped production environments of developing countries like Ethiopia which are basically low-input and low output environments.

Ethiopia has diverse agro-climatic conditions, vast resources in livestock and a huge human population, which necessitates the introduction of appropriate interventions to enhance productivity for increased food production to meet nutritional self-sufficiency and to attain national economic development. The trend of rapidly increasing human population together with growing urbanization and income created even greater markets and increased the demand for milk and milk products in Ethiopia (Dayanandan, 2011).

Mass mobilizations took place at Oromia Region level starting from 2012 with a view to improve the performance of dairy sector and its contribution to the economy of the country as a whole. This calls for understanding of the efficiency level of the dairy sector and identifying factors associated with inefficiency. The results of such analysis are expected to better inform research, development and policy decisions and also help to prioritize interventions in the sector.

Many studies focus on technological constraints in the dairy sector including poor genotype of local breed animals, animal diseases, availability of feed, input and output markets, and related policies. The studies ignore an important source of growth - improving the technical efficiency of farmers. However, the measurement of efficiency in milk production is an important issue for dairy sector development and it gives useful information for making good decision in the use of scarce resources and for formulating agricultural policies. In the study area, there is lack of pertinent research on technical efficiency of the smallholder dairy producers and the determinants of the variability in the efficiency levels among dairy producers (Mosisa, 2014; Ajebush Defar, 2014).

Ethiopia has an immense potential for increasing livestock production, both for local use and for export purposes. However, expansion and productivity was constrained by quantitatively and qualitatively inadequate and imbalanced nutrition, sporadic disease outbreak, scarcity of water, lack of appropriate livestock extension services, insufficient and unreliable data to plan the services, and inadequate information to improve animal performance, marketing, processing and integration with crop and natural resources for sustainable productivity and environmental health (Aynalem *et al.*, 2011).

According to previous researches in Ethiopia, there also exists a wide milk yield gap among the households that might be attributed to many factors such as lack of knowledge and information on how to use new dairy technologies, poor management, climate factors and more others concerning quantity of input use and the available resource use efficiency (Zewdie *et al.* 2015; Mosisa, 2014; Lema, 2013).

Moreover, research questions like what is the existing level of efficiency of dairy farmers in the study area? What are the main causes for the existing level of inefficiency (if any)? should be answered.

1.3. Objectives of the Study

The overall objective of this study is to assess technical efficiency of cow milk production among smallholder farmers in Sululta District.

The specific objectives are:

1. To measure the level of technical efficiency in the production of cow milk in the study area, and
2. To identify the sources of technical efficiency differences in the study area.

1.4. Significance of the Study

A technical efficiency study would play a significant role in providing useful information regarding technical inefficiencies in production and helps to identify those factors, which are associated with inefficiencies that may exist. Such studies would benefit the economy by determining the extent to which it is possible to raise productivity by improving the neglected resource, i.e., efficiency, with the existing resource base and available technology.

This study shows the differences in efficiency level among farmers in the study area in the production of milk. Based on the efficiency level, the determinants of inefficiency are identified. Identification of determinants of inefficiency is important for various planning and policy purposes. In addition, empirical findings on the analysis of technical efficiency of milk are also useful for other livestock products. Therefore, results of this study are believed to be important in designing different policies that possibly enhance the living standards of small farm households, mitigate the problem of food insecurity and improve domestic and international competitiveness of small farm households of the district and country as well.

1.5. Scope and Limitations of the Study

The study area is one of the areas where dairy cows are kept by farmers for milk production. This study is conducted in only one purposively selected district (Sululta), and four randomly selected *kebele* administrations. The efficiency scores of the frontier method are only relative to the best performing farmers in the sample. Thus, the efficiency scores in this study are relative values of the best farmer in the study area. This efficiency score might be reduced if more efficient farmers from other area were included in the study. Likewise, it could be increased if less efficient farmers were included (Coelli *et al.*, 1998).

Moreover, the use of cross sectional data in technical efficiency analysis only reflects households circumstances during the given production season. This may be affected by the specific climate of the year, that is, there might be vulnerability to externalities such as unpredictable shocks and variable rainfall, disease and shortage of feed input. As a result, the use of cross sectional data may affect the findings of the study since it does not capture the inter-temporal variation in the efficiency level of the households.

The study is also limited to a single district and the analysis of technical efficiency in the production of cow milk production at household level. Allocative and economic efficiencies were not considered in this study.

1.6. Organization of the Thesis

The thesis consists of five chapters. The first chapter has already dealt with the introductory part, comprising the general background of the study, statement of the problem, objectives of the study, significance of the study and scope and limitation of the study. Chapter two presents the review of the available literature including general concepts of efficiency and productivity, technical efficiency, approaches of measuring efficiency, models of efficiency measurement and results of empirical research executed elsewhere. Chapter three was devoted to methodology used in the study. It describes the study area, type, sources and methods of data collection, the sampling design and methods of data analysis. Chapter four is concerned with results and discussions. Chapter five presents summary, conclusion and recommendations.

2. LITERATURE REVIEW

This chapter sheds light on concepts of efficiency and productivity, theoretical framework, approaches of measuring efficiency, models of efficiency measurement and different empirical studies on efficiency.

2.1. Concept of Efficiency and Productivity

Efficiency may be described as the relation between ends and means that has an application in production analysis as well as in consumption theory and demand analysis (Afriate, 1972). Economists widely distinguish between technical efficiency and allocative or price efficiency, following pioneering work by Farrell in 1957. Technical efficiency (that part of efficiency which explains the physical performance of a firm) measures the relative ability of a farmer to get the maximum possible output at a given input or set of inputs. Technically efficient farmers are those farmers that are operating on the production frontier that represents the maximum output attainable from each input level. In economic terms, technical inefficiency refers to failure to operate on the production frontier and generally is assumed to reflect inefficiencies caused by the timing and method of application of production inputs (Byerlee, 1987). Potential causes of technical inefficiency are inadequate information or insufficient technical skills, *enter alia*.

Productivity on the other hand shows the ability of the farmer to produce a given output (it may not be a maximum possible output) at a given level of input. Productivity is the quantity of a given output of a firm (e.g. a farmer) per unit of input. Hence, productivity does not show the relative performance of farmer in getting the maximum possible output given input level (Coelli *et al.*, 1998). Production is an economic process of transforming inputs into some exchangeable output in the market (Shahabi *et al.*, 2009). The technical relation which connects these factor inputs with outputs of firms, industry or the whole economy is called the production function. Production function involves and provides different concepts which are useful tools of analysis in all fields of economics especially agricultural economics. These main concepts among others include: The Average and Marginal productivity of factors of production, production elasticity and return to scale.

2.2. Theoretical Framework

The neoclassical production theory provides a framework for modeling production functions in which it is assumed that the firm is operating on the frontier. In neo-classical theory of production, the primal production function defines the maximum possible output for combinations of inputs and technology. Production is the process of transforming inputs into outputs in the form of either input for another production process or final consumer goods. The neo-classical production theory therefore, provides a basis for analyzing the factors that help explain the changes in output level.

A production function indicates a relation between quantity of output and the quantities of inputs. In microeconomic theory a production function is defined as the maximum output that can be produced from a specified set of inputs, given the existing technology available to the firms (Battese and Tsessema, 1992). It is expressed as a mathematical relationship which describes the way in which the quantity of an output depends on the quantity of inputs used. This relationship is expressed as

$$Y_i = f(X_{1i}, X_{2i}, \dots, X_{ni} | X_{ki}) \quad (1)$$

Where Y_i is output of the i^{th} firm and X_{ni} is a matrix of variable inputs; X_{ki} is a matrix of fixed inputs for a given period. But in reality and practice there other unobservable variable inputs which determine the level of output in the production process. These inputs are known as random effects and are represented by μ . Adding the term μ to equation (1) modifies it to probabilistic expression (Palanisami *et al.*, 2002),

$$Y = f(x_1, x_2, x_3, \dots, X_n) + \mu \quad (2)$$

When the nature of relation is between one factor of production and one product output, the analysis is termed as input-output analysis or factor-product analysis. It generally concern itself with nature of changes in output as the level of single factor of production changes, relative to others variables are kept constant. The factor that varies with the level of output is known as variable factor or variable input.

Production function involves and provides different concepts which are useful tools of

analysis in all fields of economics especially agricultural economics. These main concepts among others include: The Average and Marginal productivity of factors of production, production elasticity and return to scale.

Average Productivity is given by dividing total output produced by the input level. It gives the information about the average output per unit of input applied, over the entire range of input applied (Palanisami *et al.*, 2002). Marginal Productivity is the slope of the given production function. It gives information about the response of total output to additional input change at the margin i.e. it measures the change in total output that result from a very small change in one of the factor of production, keeping all other factors constant.

Apart from the above two concepts, the relationship between input and output can be expressed by the production elasticity. The production elasticity expresses the relative change in production through a relative change in the addition of input (Rasmussen, 2011).

2.3. Approaches of Measuring Efficiency

Basically there are two approaches in measuring efficiency: input oriented and output oriented. The output oriented approach deals with the question “by how much output could be expanded from a given level of inputs?” Alternatively one could ask “by how much can input of quantities be proportionally reduced without changing the output quantity produced?” This is an input oriented measure of efficiency. However, both measures will coincide when the technology exhibits constant returns to scale, but are likely to vary otherwise (Coelli and Battese, 2005).

2.3.1. Input Oriented Measure

In his first work on efficiency, Farrell (1957) illustrated his idea about measuring efficiency with using figure, as follow.

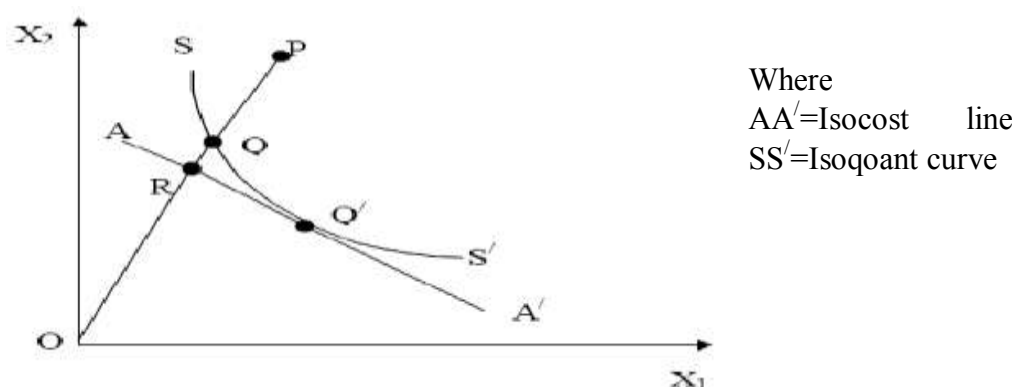


Figure 1. Measure of Technical Efficiency

Source: Farrell (1957)

The SS' is an isoquant, representing technically efficient combinations of inputs, X_1 and X_2 , used in producing output Q . SS' is also known as the best practice production frontier. AA' is an isocost line, which shows all combinations of inputs X_1 and X_2 to be used in such a way that the total cost of inputs is equal at all points. However, any firm intending to maximize profits has to produce at Q' , which is a point of tangency and representing the least cost combination of X_1 and X_2 in production of Q . At point Q' the producer is economically efficient.

Suppose a farmer is producing his output depicted by isoquant SS' with input combination level of X_1 and X_2 . Production at input combination at point P is not technically efficient because the level of inputs needed to produce the same quantity is Q on isoquant SS' . In other words, the farmer can produce at any point on SS' with fewer inputs (X_1 and X_2), in this case at Q in an input-input space. The degree of TE of such a farm is measured as OQ/OP , which is proportional in all inputs that could theoretically be achieved without reducing the output. Hence all farmers that produce along the isoquant are 100 percent technically efficient.

2.3.2. Output Oriented Measure

In the output oriented perspective, efficiency is evaluated keeping inputs constant. According to (Farrell, 1957), output oriented measures can be illustrated by considering the case where production involves two outputs (Y_1 and Y_2) and a single input (L). If the

input quantity is held fixed at a particular level, the technology can be represented by a production possibility curve in two dimensions as follows:

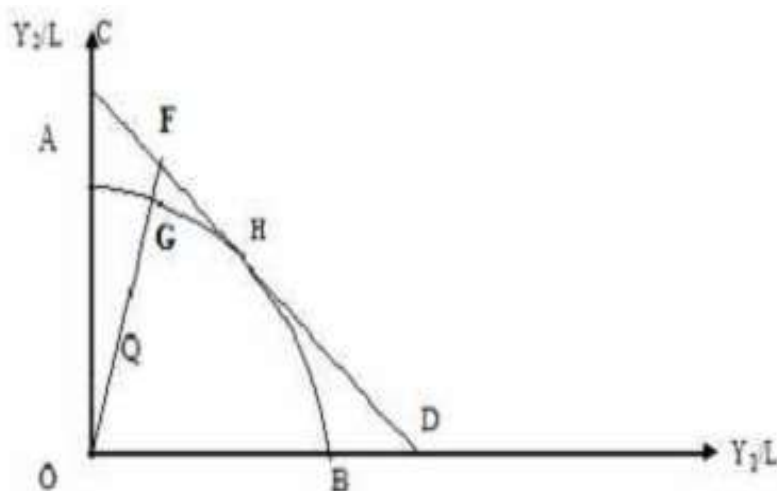


Figure 2. Output oriented measures for technical efficiency

Source: Coelli, Rao, and Battese (1998).

The production possibility curve is represented by the curve AB in Figure 2, which represents technically efficient combinations of production of outputs Y_1/L and Y_2/L . Given same level of input (L), it is not efficient to produce at point Q. considering a firm situated at point Q, the TE can be calculated as OQ/OG . Alternatively, all farmers producing along the production possibility curve are 100 percent technically efficient.

2.4. Models of Efficiency Measurements

Technical efficiency measurements basically are carried out using frontier methodologies, which shift the average response functions to the maximum output or to the efficient firm. These frontier methodologies are broadly categorized under two frontier methodologies; parametric and non-parametric frontier models. The parametric frontier model may further be classified into deterministic and stochastic frontier models. The parametric models are basically estimated based on econometric methods and the non-parametric technical efficiency model, often referred to as data envelopment analysis (DEA), involves the use of linear programming method to construct a non-parametric 'piece-wise' surface (or frontier) over the data (Coelli *et al.*, 1998).

2.4.1. Non-parametric Frontier Models

The non- parametric technical efficiency models are also referred to as data envelopment analysis (DEA). DEA employs linear programming methodology to construct the efficient frontier based on available information on the firms' inputs and outputs in the data. Thus, it is free from functional form restriction and distributional assumptions which are rather important in SFA. The lack of assumptions about the underlying production technology makes DEA suitable to accommodate problems that may arise from such restrictions. However, the use of linear programming in DEA which does not allow decomposing the stochastic noise from the inefficiency effect is one major deficiency of the approach. Those who are not on the efficient frontier are considered to be inefficient; and such deviations are attributed only to inefficiency (Erkoc, 2012).

Furthermore, the fact that this method is nonparametric makes it vulnerable to measurement errors and outliers. As a result, it has been argued that DEA is less convenient for applications particularly in developing country agricultural setting where data quality is doubtful and such measurement errors are much pronounced (Erkoc, 2012, and Coelli, 1995).

2.4.2. Parametric Frontier Models

2.4.2.1. The deterministic model

Aigner and Chu (1968) considered the estimation of a parametric frontier production function in input/output space. They specified a Cobb-Douglass production function (in log form), for a sample of N firms defined as follows:

$$\ln Y_i = f(X_i, \beta) - U \quad i = 1, 2, \dots, N \quad (3)$$

Where $\ln Y_i$ is natural log of the output of the i^{th} firm; X_i is a vector of input quantities used by the i^{th} firm; β is a vector of unknown parameters to be estimated; $f(.)$ denotes an appropriate function (in this case a Cobb-Douglas); it is not necessary to restrict the production function to Cobb-Douglas. This functional form is chosen to be consistent with

Aigner and Chu (1968) for convenience. Alternatively, the flexible translog production function, which is linear in the parameters, can also be specified; and U_i is a non-negative random variable associated with technical inefficiency in production of firms in the industry involved.

The deterministic model assumes that any deviation from the frontier is due to technical inefficiency. Hence when there is high random error on the data or where there are few outliers, the inefficiency estimates will be exaggerated as compared to other models, which take into account random errors Neff *et al.* (1993) and Apezteguía and Garát (1997) in their comparative studies of frontier models found that deterministic frontier model generate higher technical inefficiency indices than stochastic frontier model. This is because the observed input and output quantities may not only deviate from some imaginary frontier through inefficient management (as in a deterministic interpretation) but also through noise.

In general, most empirical studies on technical efficiency analysis in agriculture used stochastic frontier model due to the very nature of agricultural output, which is affected by natural hazard, climatic condition and measurement errors that could attribute to the presence of noise in the data. Hence most recent studies on technical efficiencies in agriculture have used stochastic frontier model to account for random noise (Fekadu, 2004).

2.4.2.2. Stochastic frontier model

According to Burhan *et al.* (2009), the parametric stochastic frontier function both embraces technical inefficiencies of the production process and the probabilistic random effects leading to productive inefficiency. In this sense, there appears a composite error term involving technical inefficiency and random effects. Therefore, stochastic frontier functions enable the researcher to measure both the technical efficiency sources and impact of measurement errors or factors that are not directly related with production process itself.

In order to avoid the problem associated with random error Meuse and van den Broeck (1977) proposed the stochastic frontier production function of the following form:

$$\ln y_i = \beta_0 + \sum_{n=1}^N \beta_n \ln x_{ni} + v_i - u_i \quad (4)$$

Where y_i is the maximum output obtainable from x_i , a vector of (non-stochastic) inputs, and β_0 is an unknown parameter vector to be estimated v_i is a random error having zero mean, which is associated with random factors (e.g., measurement errors in production, weather, industrial action, etc.). These are factors outside the control of the smallholder farmers. The model is such that the possible production y_i , is bounded above by the stochastic quantity, $y = f(x_i; \beta) \exp v_i$ hence the term stochastic frontier. The random errors V_i , $i = 1, 2, \dots, N$, were assumed to be independently and identically distributed as $N(0, \sigma^2 v_i)$ random variables, independent of the u_i 's, which were assumed to be non-negative random variables which are independently and identically distributed as $N(0, \sigma^2)$ distribution (i.e., half-normal distribution) or have exponential distribution which reflects technical inefficiency to the frontier production of milk which is the ratio of observed output to maximum feasible output of the i^{th} household.

The distribution of u_i is half normal with mean u_i and variance. Given the assumptions of the stochastic frontier model, inference about the parameters of the model can be based on the maximum-likelihood estimators because the standard regularity conditions hold. Aigner (1977) suggested that the maximum-likelihood estimates of the parameters of the model be obtained in terms of the parameterization, $\sigma^2 = \sigma^2 v + \sigma^2 u$ and $\lambda = \sigma u / \sigma v$. Rather than using the nonnegative parameter (i.e., the ratio of the standard deviation of the $N(0, \sigma^2)$ distribution involved in specifying the distribution of the nonnegative u_i 's to the standard deviation of the symmetric errors v_i).

Battese and Corra (1977) considered the parameter, $\gamma = \sigma^2 u / (\sigma^2 v + \sigma^2 u)$ which is bounded between zero and one. As it could be envisaged, the parameter λ is an indicator of the relative variability of the two sources of variations. If λ is closer to zero the symmetric error term dominates the variation between the frontier and the observed level of output or put differently, a value of λ close to zero implies that the discrepancy between the observed and the maximum attainable levels output is dominated by random factors outside the control of the producer. Otherwise, the more λ is greater than one the more the production is dominated by variability emanating from technical inefficiency.

The main advantage of this model is the ability of the model to separate the random error or noise, such as weather that are stochastic and not due to operator inefficiency, from deviations arising from technical inefficiency. Due to this, most empirical studies especially in agriculture where random errors due to random shock and measurement error are high focus on stochastic frontier model. Coelli *et al.* (1998) recommended that SPF is more appropriate than DEA and deterministic models in agricultural applications, especially in developing countries, where the data are heavily influenced by measurement errors, and the effect of weather, disease, etc plays a significant role.

The other attractive feature of stochastic frontier model is that it permits the estimation of standard errors and test of hypothesis using traditional maximum likelihood methods which were not possible with the deterministic model because of the violation of certain maximum likelihood regularity conditions. However, a serious shortcoming with parametric frontier methodology in general is that there is no priori justification for the selection of any particular functional form for the inefficiency term, u_i . Parametric frontier methodology requires selection of specific functional form, which may not hold (Coelli *et al.*, 1998).

2.5. Estimation Stages of Determinants of Technical Efficiency

A single stage estimation procedure was followed to analysis determinants of TE from a stochastic frontier production function. In single stage estimation, inefficiency effects are defined as an explicit function of certain factors specific to the firm, and all the parameters are estimated in one-step using the maximum likelihood procedure. The major drawback with the two-step approach resides in the fact that, in the first step, inefficiency effects are assumed to be independently and identically distributed in order to use the approach to predict the values of technical efficiency indicators (Jondrow *et al.*, 1982). In the second step, however, the technical efficiency indicators thus obtained are assumed to depend on a certain number of factors specific to the firm, which implies that the *TE* are not identically distributed unless all the coefficients of the factors considered happen to be simultaneously null. The two-stage procedure produces inconsistency in the assumption (Coelli *et al.*, 1998).

2.6. Empirical Studies on Technical Efficiency

Zewdie *et al.* (2015) analysed sources of technical inefficiency of smallholder farmers in milk production in Ethiopia by using the maximum likelihood estimates of the stochastic production frontier function and the technical inefficiency model. The number of cows owned during the production year, number of labour available for dairy production and management, purchased supplements such as concentrates and industrial by-products, ownership of crossbred cows and the agro-ecological zone have positive and significant effects on the amount of milk production. The result also indicates that coefficients associated with education, household wealth, and distance to district town (proxy for access to input and output markets and institutions) are statistically significant with expected signs.

Masunda and Chiweshe (2015) used a stochastic frontier investigated the farm level technical efficiency of production and its determinants in Zimbabwe dairy farming. The mean technical efficiency was estimated to be 54.9% for the sampled data indicating gross inefficiencies on the part of dairy farmers. Using a stochastic frontier production function, the empirical evidence suggests the critical factor in explaining output is herd size. In establishing the factors affecting farm level technical efficiency farming experience, gender, age, market performance and veterinary and extension services are particularly important determinants.

Nakanwagi *et al.* (2015) analysed technical efficiency of milk producers in cattle corridor of Uganda, the case of kiboga district, using stochastic frontier production function and the Cobb Douglas functional form. Major determinants of technical efficiency among milk producers were water source/valley tank at farm and possession of cross/exotic cows, attributed by the large coefficient values as compared to those of other variables in the model. But hired labour use, land ownership, farm water source and access to extension services had a positive and statistically significant effect on technical efficiency of sampled milk producers.

Kimenchu *et al.* (2014) had evaluated technical efficiency of dairy farms in eastern central highlands of Kenya. The number of milking cows and quantities of roughages, concentrates and mineral supplements fed, determine the amount of milk a farm produces.

The dairy farm efficiencies ranged between 37.2 and 96.9%, with mean estimate of 83.7%, implying that one can lower the milk production inputs by 16.3% without reducing the milk output quantities. A proportionate doubling of all the inputs in use at the moment could more than double a farm's milk yield.

Mosisa (2014) analysed the technical efficiency of milk production in Bale zone of Oromia region, Ethiopia. He applied a Cobb-Douglas stochastic production frontier analysis approach and Tobit model to estimate level of technical efficiency and identify determinants of technical efficiency variation of the farmers in milk production, respectively. The result of his study revealed that milk output was positively influenced by the number of cows, concentrate supply and human labor used.

Al-Sharafat (2013) analysed technical efficiency of dairy farms in Jordan using a stochastic frontier model. Farmer's level of education, farmer's farming experience, farmer's contact with an extension services and herd size are the main determinants associated with TE in the sampled dairy farms. Technical efficiency can be further improved through provision of education, training and orientation of the farmers toward dairy farming practices. There is a need to improve farmers' access to extension services. The need to involve farmers more in the extension process itself should be encouraged.

Bardhan and Sharma (2013) used stochastic frontier production function analysis to estimate technical efficiency of milk production in India. In the hills, small farmers were more efficient (mean efficiency of 90.31%) than their medium counterparts (mean efficiency of 85.49%). Mean potential to increase efficiency for small and medium category farmers in the hills were 8.62% and 14.01 per cent. Mean potential to increase efficiency for overall category was 10.01%. This implies, that if the average farm in the hills was to achieve the technical efficiency level of the most efficient farm, then the average farm would realize a 10.01% cost saving.

Lemma *et al.* (2013) examined determinants of technical efficiency of the dairy farmers in Ada'a district, Ethiopia by using the maximum likelihood estimates (MLE) of the Cobb-Douglas stochastic frontier production. The estimates suggest that mass media exposure of the dairy farmers, training on dairy farming, dry fodder and concentrate feeds were the significant determinants of technical efficiency of milk production in the study area.

Educational level of the farmer, organizational participation of the dairy farmers, experience of the dairy farmers in dairy farming and labor had also positive relationship with the technical efficiency of milk production.

Amlaku *et al.* (2013) examined innovation and technical efficiency in the smallholder dairy production system in Ethiopia by using Cobb-Douglas stochastic frontier production in 2011 milk production year in four districts of the Amhara region. This result suggests that there is room for significant increases of production through reallocation of existing resources. Despite significant variation among farmers, these results also indicate only 19% of farmers have mean efficiency scores ($\geq 50\%$), implying a need to focus on creating innovation capacity that pushes the production frontier outward in the dairy production system. It is also revealed that individual farm households' efficiency varied widely across dairy technology adoption status, gender and districts.

Dayanandan (2011) used Cobb-Douglas production, cost-benefit and break-even ratios to assess resource use efficiency, profitability and financial efficiency of both cross and local breeds. Farms owning 1-3, 4-10 and greater than 10 dairy cows were classified as small, medium and large farms, respectively and only small and medium size farms were considered in the study. The results indicate that the regression coefficients with respect to concentrate for medium and small size cross breed farms are positive and significant at 10% level. The coefficient of dry fodder for medium size cross breed and local breed are positive and significant at 10% level.

Demircan *et al.* (2010) investigated dairy farm production and reported it at a low level of technical efficiency in Burdur province (Turkey). Using Data Envelopment Analysis they found that forage feed and labor inputs are used most inefficiently. A statistically significant and positive relationship between a herd size and efficiency underscore the importance of larger herd size to catch benefit of economies of scale. In contrast to expectation, negative and statistically significant relationship was found between forage feed, land size and production efficiency.

2.7. Conceptual Framework

Production process involves a transformation of inputs into outputs. Inputs as well as outputs vary from one type of production to another. In milk production, inputs include number of cows, labor, dry fodder, green fodder and concentrate, which are all combined in different ratios to produce outputs. The effectiveness with which the inputs are transformed into outputs does not only depend on inputs used but also on the managerial practices that the farmer uses to combine these inputs.

Studies by Jema (2006) showed that efficiency of production was determined by the host of socio-economic and institutional factors. These factors directly/indirectly affect the quality of management of the farm's operator and, therefore, are believed to have impact on the level of technical efficiency. According to Bakhsh (2007), a range of factors like distinctiveness of farms, management, physical, institutional and environmental aspects could be the cause of inefficiencies in the production process of the farmers.

Managerial practices are influenced by farm and farmer characteristics, which together with the inputs determine the quality and quantity of outputs produced. Households are the decision making units where all decisions on types and amounts of inputs to be used in production process and managerial practices to be done are made. The decisions made in turn influence how inputs are efficiently transformed into outputs i.e. technical efficiency. This scenario is represented in a pictorial form as a conceptual framework (Figure 3) to guide this research.

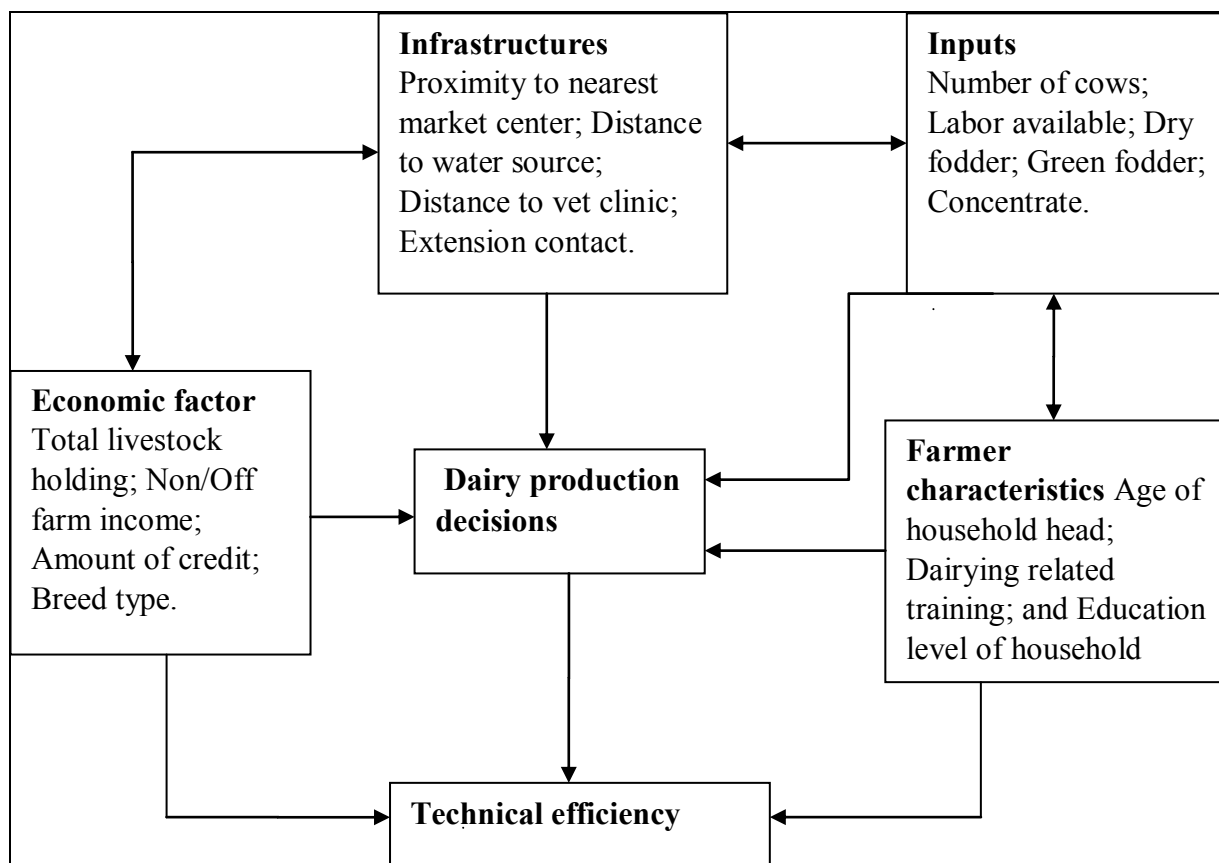


Figure 3. Conceptual framework for efficiency analysis

Source: Own construction 2016.

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

Sululta district is one of the six districts of Oromia Special Zone Surrounding Finfinne, Oromia National Regional State Ethiopia. The district is bordered with different districts of North Shewa zone; Welmera in the west, Wuchale in the north, Jida in the east and Addis Ababa city administration in the south. The altitude of the district ranges from 2851 to 3700 meters above sea level.

Population of the district was about 148,700 persons (male 72,863 and female 75,837) CSA (2015). Concerning the land use pattern, out of the total area of the district which is 111,466 ha, about 28,859 ha (24.9%) is cultivated land, 15,145 ha (13.6%) is covered by forest, bush and shrub land, 38,720 ha (34.7%) is grass lands, and 28,742 (25.8%) are other land use types (SDAO, 2016).

The highest annual rainfall is 1447 mm with mean of 1140 mm and minimum of 834 mm. In the area, the months with high rainfall are July to September with low temperature, whereas the temperature is high in the months between Decembers and March.

The farming system of the district is rain-fed and mixed agriculture. Livestock husbandry and crop production are the predominant economic activities and the major sources of livelihoods in the district. The main farming activity is livestock rearing followed by crop production, mostly cereal crops such as barley, wheat, *teff*, and pulse crops such as horse bean, pea, lentil and others. The livestock feed resource is hay, crop residue and grazing land. The total cattle population in the district is estimated at 224,600 (15% are cross-breed) (SDAO, 2016).

The district has 23 *kebele* administrations, 4 sub-towns (Chanco, Dubar, Sululta and Derba), and 22 Farmer Training Centers, 64 development agents and 68 different types of cooperatives. From these cooperatives in the district, 12 are primary dairy cooperatives affiliated to the Selale Dairy Cooperative Union (SDAO, 2016).

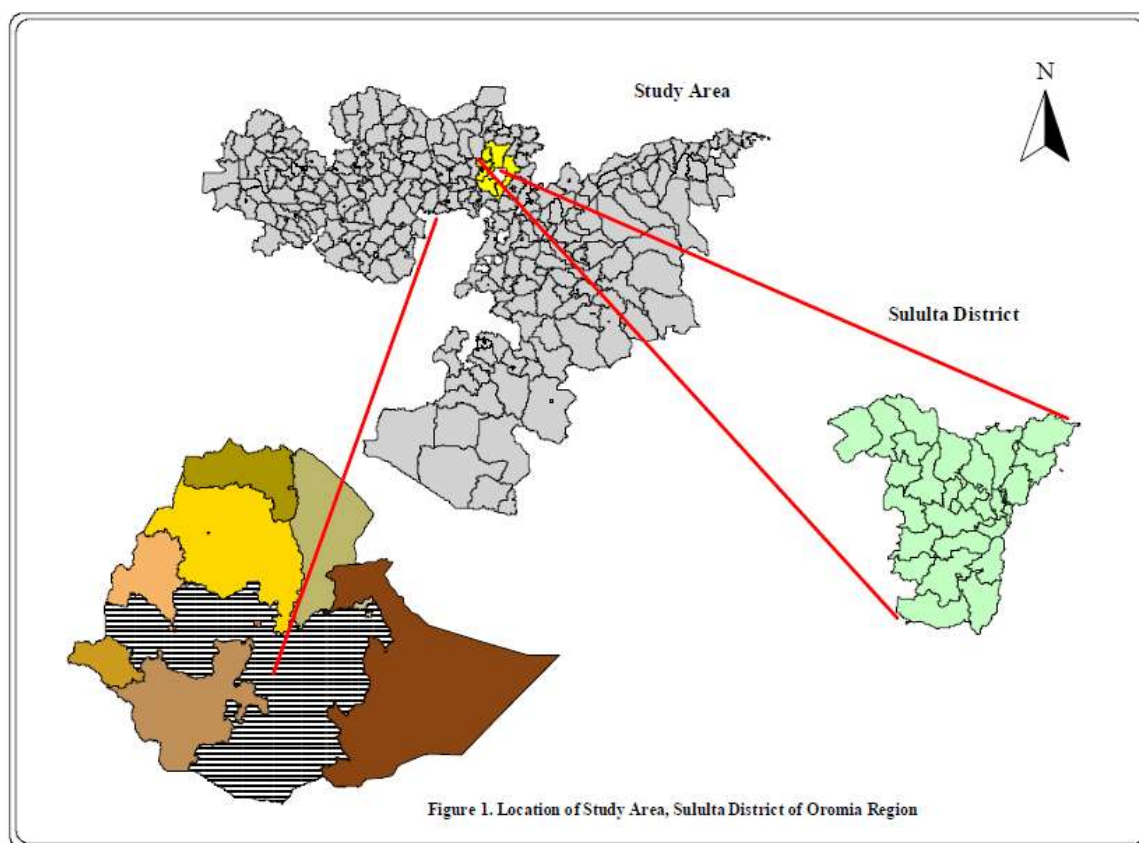


Figure 4. Map of Oromia National Regional State and the study area

Source: Ethio-GIS 2016.

3.2. Source of Data and Methods of Data Collection

This study used both primary and secondary data. The primary data were collected using structured questionnaire that was administered by trained enumerators. Pre-testing of the questionnaire was conducted so that appropriate refinements and modification of the questionnaire were made. Data collection was conducted from August to September 2016 from milk producing households on input use and milk production along with socioeconomic and institutional elements. The process of primary data collection was conducted through visits, which enabled to gather timely and reliable information on the overall dairying activities using the local language (*Afan Oromo*). This was due to the fact that, the quality and reliability of the information gathered from households depends on their recalling capacity. For example, it may be difficult for the farmer to recall the exact quantity of feed (quantity of dry fodder, green fodder, concentrate) supplied to cows and quantity of labor used as well as liters of milk produced the whole year. So it is better

inquiring households in the morning or evening at the time of real operation and sometimes in the middle of the day.

Secondary data were collected from relevant sources such as, open web sources, bulletins, published articles and related documents from the district office of agriculture and relevant organizations.

3.3. Sampling Technique and Sample Size determination

Sululta district has been purposively selected from the study zone based on the extent of milk production. Then multi-stage stratified random sampling technique was implemented to draw representative sample size. Sululta district comprises of 23 *kebele* administrations (KAs) and 4 sub towns. In the first stage, four KAs were selected randomly and sampling frame has been constructed on the basis of a list provided by the district agricultural office. In the second stage, following the establishment of a sampling frame, dairy producers and non producers were stratified. In the third stage, dairy producers were stratified into producers owning local and crossbred cows.

Finally, the required sample size was determined using the formula given by (Cochran, 1977), to draw an adequate sample size from a given population at 5 percent error and 95 percent confidence level. The procedure is as follows:

$$n_0 = \frac{Z^2 \cdot p \cdot q}{e^2} \quad (5)$$

Where n_0 the desired sample size, z is the desired confidence level (the value corresponding to the 95 percent level of confidence i.e. 1.96), e is the desired level of precision (maximum margin of error i.e. 5%), and p is the estimated proportion (degree of variability) of an attribute that is present in the population. The total population of milk producing farmers having local cows and crossbred cows in all 23 KAs and four sub towns of the district was about 12,217 in which the size of milk producing farmers in the sample four KAs are about 9.3 percent and $1 - P$ is about 90.7 percent. Therefore, the study used the procedures stated in the above equation to collect the primary data and to maintain sufficient sample size.

Accordingly, a total of 130 milk producing households were randomly drawn using probability proportional to size (PPS). Table 1 below shows the size of sample households selected from each KAs.

Table 1. Sample distribution in selected four kebeles

Name of Kebeles	Number of dairy cows owners	Percent	Total sample size
Warerso Malima	251	22	29
Chanco Buba	284	25	32
Gorfo	311	27	36
Rob Geba	292	26	33
Total	1137	100	130

Source: own computation result based on data (columns 2 and 3) obtained from SDAO 2016.

3.4. Methods of Data Analysis

To achieve the objectives of the study, data obtained were analyzed using descriptive statistics and econometric models.

3.4.1. Descriptive Analysis

Descriptive statistics, such as mean, standard deviations, percentage and frequencies were used in analysing the socioeconomic characteristics, institutional characteristics and the distributions of efficiency levels.

3.4.2. Econometric Analysis

A farmer may deviate from the frontier not only because of measurement error, statistical noise or any other influence but also because of technical inefficiency. This divergence could be related to various factors. Therefore, it is important to identify factors which influence the technical efficiency of the dairy households to further intervene and increase milk production. To assess such conditions, stochastic frontier model proposed by Battese and Coelli (1995) in accordance with the original models of Aigner *et al.* (1977) and Meesuen and van den Broeck (1977) are applied to cross-sectional data of 2015/16 to

determine technical efficiency in milk production in the study area. Thus, the stochastic efficiency decomposition methodology is chosen as more appropriate for this study. The stochastic frontier production function can be written as:

$$\ln Y_i = \beta_0 + \sum \beta_j \ln X_{ij} + V_i - U_i \quad i = 1, 2, \dots, N \quad (6)$$

Where: $\ln$ = the natural logarithm (i.e., to base e); Y_i = is milk output in liters of milk produced by i^{th} household per year; X_i is vector of input for household i , β_0 is the level of milk output from cows without any additional feed supplement /only grazing or the intercept/ and the other β_j 's constitutes a vector of parameters to be estimated. V_i , is a symmetric error term accounting for the deviation from the frontier because of factors which are beyond the control of the farmer (such as variation in weather, measurement error and other statistical noise) and U_i , is a one sided error term accounting for the deviation because of efficiency effects. V_i 's are independently and identically distributed normal random variables with zero means and variances σ^2 , i.e. $v_i \sim \text{iid } N(0, \sigma_v^2)$ and U_i 's are non-negative/one sided random variable ($U_i \geq 0$) efficiency component that captures/measures the deviation from the maximum potential output given by the stochastic frontier output $f(X_{ij}; \beta) + V_i$, attributable to technical efficiency.

There are different functional forms to represent the production frontier. The two commonly used functional forms are Cobb-Douglas and Translog, each having their merits and demerits. Both models overwhelmingly dominate the applications literature in stochastic frontier and econometric inefficiency estimation (Coelli *et al.*, 2006). However, the work by Kopp and Smith (1980) confirmed that if the interest lies in measuring technical efficiency and not in the analysis of general structure of the production function, the functional form will have insignificant impact on measurement of efficiency. Cobb-Douglas is selected because the number of parameters involved would be so high if translog is specified. Thus, Cobb-Douglas frontier function is specified as follows:

$$\ln(OUTP) = \beta_0 + \beta_1 \ln(COW) + \beta_2 \ln(LAB) + \beta_3 \ln(DFODDER) + \beta_4 \ln(GRFODDER) + \beta_5 \ln(CONC) + V_i - U_i \quad (7)$$

v_i - is the disturbance error term, independently and identically distributed as $N(0, \sigma_v^2)$ intended to capture events beyond the control of farm household; and

μ_i - is a non-negative random variable, independently and identically distributed as $N(\mu, \sigma_v^2)$ intended to capture technical inefficiency effects in the production of milk measured as the ratio of observed output to maximum feasible output of the i^{th} cow.

μ_i - is assumed to follow half-normal distribution with mean μ_i and, σ^2 , such that

$$\mu_i = \delta_0 + \delta_1 tlu + \delta_2 educ + \delta_3 frexten + \delta_4 distvet + \delta_5 distma + \delta_6 bredty + \delta_7 trg + \delta_8 amcredit + \delta_9 landho + \delta_{10} grland + \delta_{11} agehh + \delta_{12} age^2 hh + \delta_{13} distwa + \delta_{14} offarm + w_i \quad (8)$$

Where the variables used in the above inefficiency model are defined as follows:

μ_i - is the inefficiency score of the i^{th} household;

δ_i - is a vector of parameter to be estimated;

w_i - is an error term;

The one-stage estimation procedure of the inefficiency effects model together with the production frontier function is implemented in the study. The two-stage procedure produces inconsistency in the assumption (Coelli *et al.*, 1998). Thus one-stage procedure is selected for this study. The maximum likelihood estimates of the parameters of the frontier model are estimated, such that the variance parameters are expressed in terms of the parameterization:

$$\sigma_s^2 = \sigma_v^2 + \sigma_u^2 \quad \text{and} \quad \gamma = \sigma_u^2 / \sigma_s^2 = \sigma_u^2 / \sigma_v^2 + \sigma_u^2 \quad (9)$$

Where: the γ parameter has a value between 0 and 1. A value of zero indicates that the deviations from the frontier are entirely due to noise, while a value of one would indicate that all deviations are due to technical inefficiency.

σ_u^2 - is the variance parameter that denotes deviation from the frontier due to inefficiency;

σ_v^2 - is the variance parameter that denotes deviation from the frontier due to noise, and

σ_s^2 - is the variance parameter that denotes the total deviation from the frontier.

$$\text{Technical efficiency (TE)} = Y_i / Y_i^* = f(X_i, \beta) \exp(V_i - U_i) / f(X_i, \beta) \exp(V_i)$$

$$= (\exp) (-U_i) \quad (10)$$

Where:

Y_i = observed Output.

Y_i^* = Frontier Output.

i : denotes a household, TE: technical efficiency of the i^{th} household, $\exp (-u_i)$: expected value of $-u_i$. Technical inefficiency relative to the stochastic production frontier is captured by the one-sided error component $\exp (-U)$, $U \geq 0$. The condition $U \geq 0$ ensures that all observations lie below the stochastic production frontier (Khairi and Battese, 2005).

The model is estimated by using stochastic production function and the Maximum Likelihood Estimates (MLE). Frontier software developed by Coelli (1996) FRONTIER 4.1 has been used to estimate simultaneously the parameters of the stochastic production frontier and the technical inefficiency effects.

Hypotheses tests

The following general hypotheses tests are conducted for the parameters of the frontier models of milk producing farmers in the study area:

1. Technical efficiency effects are not present in the production of milk in the study area represented by the frontier production function (that is, $H_0: \gamma = 0$ versus $H_1: \gamma > 0$); and,
2. All the explanatory variables included in the efficiency effect model do not have an influence on the technical efficiency variation (that is, $H_0: \delta_0 = \delta_1 = \delta_2 = \delta_3 = \dots = \delta_{14} = 0$).

These hypotheses will be tested using the generalized likelihood ratio test and generalized likelihood ratio statistic, λ is defined by:

$$LR(\lambda) = -2 \{ \ln [L(H_0) / L(H_1)] \} \text{ or } -2 [L(H_0) - L(H_1)] \quad (11)$$

Where: $L(H_0)$ = value of the likelihood function under null hypothesis and

$L(H_1)$ = value of the likelihood function under alternative hypothesis.

This test statistics is asymptotically distributed as a Chi-square (or mixed Chi-square) random variable with a degree of freedom equal to the number of restrictions involved (Coelli *et al.*, 1998).

3.5. Definition and Measurement of Variables with Hypothesis

This study addressed both production and inefficiency variables. The identification of important variables used for the estimation of frontier model were selected based on observing the characteristics of milk production of the study area and through review of relevant economic theory and empirical literature on milk efficiency analysis.

3.5.1. Production Variables

Dependent variable

Size of milk output: The total milk produced on average (in litres) per cow by the sample household during 2015/16 production year is considered as the dependent variable.

Input variables of production functions

The following variables are treated as independent variables of the production function.

Number of lactating Cows (NCW): Total number of lactating cows of the household during the 2015-16 production seasons primarily kept for milk production in the study area. This production variable is measured by number of cows (local breed and cross-bred) per household. Bardhan and Sharma (2013) claimed that an increase in the number of cows would result in an increase in output. Therefore, it was hypothesized that the number of lactating cows has a positive effect on the technical efficiency of cow milk production.

Green fodder (GRF): It includes mostly wet natural grass used by the households in the study area. The supply is mainly during rainy seasons. Green fodder supplied to lactating cows through cut and carry system is measured in kilograms per household per year. Kimenchu *et al.* (2014) and Lemma *et al.* (2013) made evaluation on technical efficiency of dairy farm and pointed out that dependence on rain-fed fodders and pastures on small

land sizes was a plausible reason for inadequate roughages. Hence, it was hypothesized that this variable does positively affect technical efficiency of milk production.

Dry fodder (DRF): Dry fodder can be in the form of straw of barley, wheat, *Teff* stalk and hay. Most farmers use a combination of the above fodder types at harvest time and store to be utilized in the forthcoming dry period. One fodder type can be a substitute for the other and dry fodder supplied to the lactating cows is measured per household per year in kilograms. According to Zewdie *et al.* (2015) the estimated coefficient of dry fodder was positive and significant implying that increase in the amount of dry fodder results in an increase in the technical efficiency and influences the milk production positively.

Concentrate (CNT): Concentrate is one of the feed types used in the dairy farm in the study area and measured in kilogram. The commonly used concentrate feed, in the areas, are oil seed cakes (noug and linseed cakes). Concentrate feed supplied to the lactating cows are measured per household per year in kilograms. Nakanwagi *et al.* (2015) found that concentrate had positive effect in milk production. Based on their findings, it was hypothesized that the quantity of concentrates fed to dairy cows could positively influence milk yields in the study area.

Labour (LAB): It refers to total number of labour in man day specifically used for dairy production by each household. Amount of Labour (family and/or hired labour) is measured per household during the production year 2015/16 (expressed in man-days) represents this variable. According to Al-Sharafat (2013) and Masunda and Chiweshe (2015) the availability of labour supply has been found to be one of the important factors for milk production at household level. This means that the higher the number of able workers per household available to manage the cows the higher could be the milk output by the household. Therefore, it was hypothesized that availability of labour does influence technical efficiency of milk production positively.

3.5.2. Efficiency or Inefficiency Variables

Factors included in the model are categorized as socioeconomic, institutional and household specific factors that can affect milk production in efficiency of dairy cows owners either positively or negatively. They are specified as follows:

Age of the household head (AGEHH): This is a continuous variable measured in years included to estimate the effect of milk producers' age on technical efficiency and it is used as a proxy for producer's experience. Age can also reflect the capacity the farm operator has to engage in farming activities. In this regard it is assumed that young farmers lack experience and motivation towards farming, whereas old farmers face labour shortage to work on those laborious farm activities. In addition, older producers may insist on sticking to old practices or take long to accept new technologies that would improve operation efficiency as they tend to be risk averse (Feng, 2008). Lemma *et al.* (2013) reported that farmers with older age were found to be technically less efficient in producing milk. To see the diminishing effect of age on efficiency a quadratic functional form is specified in the inefficiency effects model. Hence, the age and the age-square are hypothesized to have a positive and a negative influence technical efficiency, respectively. If this is true we can conclude that middle age farmers are more efficient in cow milk production than others.

Education level of the household head (EDUHH): is the education level of a household head measured in continuous class years of school. It is assumed that through education the quality or ability of the farmer will be improved because education enables farmers to have access to new information and idea relevant to organizing productive resources. In addition higher level of education could guide better management of farm activities. Amlaku *et al.* (2013), Lemma *et al.* (2013) and Mosisa (2014) have found that years of exposure to education had positive influence on technical efficiency. It was, therefore, hypothesized that education contributes positively towards technical efficiency of cow milk production.

Frequency of Extension contact (FREXCN): This variable is treated as a continuous variable and measured by the number of visits made by the extension agents to sample households during 2015/16 production year. According to Lemma (2013) farmers who have contacts with extension agents will get the timely suggestions making themselves more efficient in the operation and milk production. Extension services increase efficiency through improving their farm management skills and knowledge acquisition on new practices (Awunyo-Vitor, 2013). Thus, the variable was expected to have a positive effect on the technical efficiency of cow milk production.

Distance to nearest veterinary clinic (DISTVET): It is a continuous variable that captures a walking distance to the available clinic place/town from the household's homestead and it is measured in kilometres. It is expected to determine the efficiency of household milk production. Cattle travelled long distances to get treatment from distant clinic post will have an imposed stress on the lactating cows especially the exotic breeds (Ngongoni, 2006). Far distance can also cause less frequency to treat the livestock. Hence, it was hypothesized that distance to clinic affects milk production efficiency in negative case.

Proximity to nearest market center (DISTMA): is the distance in kilometres a producer or farm workers travel to the nearest market centers to sell milk and buy production inputs like milk cans, veterinary drugs, salt feed, and others. Long distances reduce the price of marketed milk and increase input prices as a result of the high cost of transportation incurred in moving milk output and inputs. Feng (2008) and Zewdie *et al.* (2015) reported that distant households with respect to major markets and administrative centers would have less access to market and institutions which could be associated with inefficiency. So it was hypothesized as proximity to the nearest market center would influence the milk production efficiency in positive case.

Breed type (BRETY): It may be local breed or cross bred cows and considered as a dummy variable taking a value of 1 for cross breed and 0 otherwise. The farmers having more crossbred livestock tend to be more efficient. The sample households keep both local and crossbred dairy cows. This could be explained in terms of a high milk yield by the crossbred livestock as compared to the local ones, leading to a higher milk production and efficiency of farmers. MOR and Sharma (2012) and Nakanwagi *et al.* (2015) also testify that possession of cross/exotic cow had a positive and significant influence on technical efficiency of milk producers. From their finding, farm that was using at least one improved cow for milk production had higher technical efficiency than a farm which was relying only on local cows for milk production. Therefore, it was hypothesized that ownership of crossbreed cows would affect the efficiency of milk production positively.

Training on dairy farming (TRDAFA): It was represented as a dummy variable taking a value of 1 if a household got training and 0, otherwise. Training on dairy farming refers to the training given to farmers on some improved dairy husbandry practices or

protecting animals from disease etc. Training increases the awareness of farmers and exposes managers to new ideas and information about productivity of inputs, opportunities, input and output management and prudent handling of cash. Following these arguments Lemma *et al.* (2013) and Mosisa (2014) have reported positive association between participation in training and efficiency of milk production. Farmers who received training were hypothesized to be more efficient than those who did not receive training.

Total livestock holding: It is the total number of livestock holding of the household excluding lactating cows and a continuous variable measured in TLU. This variable is also entered as a proxy variable for the wealth status of the households. Livestock are source of income for farming households. Demircan *et al.* (2010) and Tauer (2001) reported that herd size is positively related to efficiency. According to Derib (2010) total herd size exerts a positive impact on the level of income from livestock for the household. Therefore, it was expected that, larger number of livestock and efficiency of household are positively related.

Credit Use (CREDUS): This is a continuous variable which refers to the amount of credit received and utilized by households from different organizations like micro finance institution, cooperatives and other institutions operating in the area. If farmers have poor access to credit, they may be unable to get enough input for their livestock, pause to dig up some improved practices and acquire breed type, livestock health treatment etc. Anteneh (2006) claimed that due to lack of capital, households are not able to introduce the crossbreds into their herds. As most households are poor, in the study area, credit utilization is expected to contribute to stimulate the households' uptake of the improved breed. Hence, it was hypothesized that the amount of credit utilization and efficiency of milk production are positively related.

Availability of grazing land (GLAND): it is defined as the total area of private grazing land in hectares. According to Zewdie (2015) as the size of grazing land increases it is expected that the available pasture grass will increase which may further contribute to higher milk production. Derib (2010) reported that the relationship between livestock income and availability of grazing land is significant and the implication of the analysis result is that grazing pasture is the major inputs for healthy livestock production. It refers to the availability of grazing land in required quantity and quality in nearby areas. It was

hypothesized that availability of grazing land will have positive impact on the efficiency of milk production in the study area.

Landholding size (LNDHOL): It is total area of cultivated land under cereal crops. It is a continuous variable which is measured in hectares. This variable represents whether or not the sample households have land for cereal crops which can make the availability of feed for dairy cows in the form of cereal by product. It is assumed that the size of land under cereal crops can affect the technical efficiency of milk. As cultivated land increases, dairy cows holder gets more by-product of cereal production (straw of Barley, Wheat, *Teff*, etc) to feed their cows. Anteneh (2006) testify that area under crop and under pasture respectively showed a unit increases in milk yield in the household and he found significant relationship with technical efficiency.

Distance to water source (DISTWA): It is the distance that shows how many kilometres households are far away from the nearest water source and its effect on the efficiency of milk production. The nearest of water source to the home of households, the higher the probability he/she can easily avail water for cows. Ngongoni (2006) concluded that the distance to water tended to affect the frequency of watering cattle. The households who lived far from the source of water reported that they drove the animals to drink water once a day, or the water was carried home using water carts (ibid). Based on the above evidences, it was hypothesized that distance to water source could affect milk production efficiency negatively.

Off/Non-farm income (NOFINC): It is a continuous variable measured in Birr for the household and/or his economically active family members engaged in any off/non-farm employment; since a household having an additional income from outside of farming activities increase their income availability. This may enable them to purchase some feed supplement for dairy cows and also serve as a source of finance for a timely health treatment which can support milk production. Masuku (2014) and Mumba (2012) revealed that income from off-farm job influences dairy farmers' decisions to expand and improve dairy operation. Hence, this variable stands for an additional income earning opportunity and it was hypothesized to have a positive relationship with efficiency of milk production.

Table 2: Definition of explanatory variables and their expected effects

Variable	Description of variable	Types	Value	Expected sign
TLU	Total Livestock Unit	Continuous	Tropical livestock unit	+ve
EDUHH	Education level of Household	Continuous	Grade	+ve
FREXCN	Frequency of Extension contact	Continuous	Number of visit	+ve
DISTVET	Distance to Veterinary	Continuous	Kilometers	-ve
PROXMA	Proximity to Market center	Continuous	Kilometers	+ve
BRETY	Breed Type	Dummy	Crossbreed only=1 Local cow only=0	+ve
TRDAFA	Training on Dairy Farm	Dummy	Trained=1, Otherwise=0	+ve
CREDUS	Amount of credit Use	Continuous	Birr	+ve
AGHH	Age of the household Head	Continuous	Number of years	+ve
GRLAND	Total Grazing land	Continuous	Hectare	+ve
LANDH	Total Land Holding Size	Continuous	Hectare	+ve
AGHH ²	Age-square of the Household Head	Continuous	Number of year	-ve
DISTWA	Distance to Water Source	Continuous	Kilometers	-ve
NOFINC	Non/Off-farm income	Continuous	Birr	+ve

Source: own definition

4. RESULT AND DISCUSSION

This chapter has two major sections. The first section presents results of the descriptive statistics. The second section deals with econometric model results of the technical efficiency analysis and provides variables that explain technical inefficiency in milk production in Sululta district.

4.1. Descriptive Statistics Results

A number of studies have suggested that the technical efficiency of rural households is determined by various socioeconomic and demographic and farm inputs, Nega and Simeon (2006), Suzanne *et al.* (2000) and Reddy *et al.* (2008). However, before embarking on analyzing their effects on efficiency, descriptive statistics of key variables is conducted and presented as follows.

4.1.1. Demographic Factors of Sample Households

Age is one of the important factors which determine management experience of the milk producing households. Therefore, it is important to discuss an age structure of household heads within the sample. The survey result showed that the average age of sample household heads was 45.37 years with a standard deviation of 16.27 years ranging from 27 to 79 years, implying that the majority of the milk producers are in their middle ages. About 91.54% of the sample households were male headed and the remaining 8.46% were female headed. Among the sample farmers considered, about 84.6% of them were married, 1.5% single, 10.8% widowed and 3.1% divorced.

4.1.2. Resource Basis

Land holdings

According to the survey result, the total land-holding of sample households, on average, was 0.89 ha with a standard deviation of 0.79 ha. The amount of land-holding of sample household ranges between zero and a maximum 3.00 ha during 2016 production year. Land is irreplaceable, scarce and a basic factor of production. It is assumed that the larger

the total area of the cultivated land the household owns, the higher would be the output and as a result higher income (Kraenzle 1989 and Klien *et al*, 1997). As the cultivated land size increases, dairy cows holder gets more by-product of cereal production (straw of barley, wheat, teff, etc) to feed their cows. Households who have large cultivated land size can have a better option to diversify and to increase by product he/she gets from the main production. So such a household will be in a better position to engage in milk production easily and efficiently.

Availability of grazing land

The grazing land holding of sample household, on average, was 0.27 ha with a standard deviation of 0.39 ranging between zero and a maximum of 1.25 ha. According to Derib (2010) the relationship between livestock income and availability of grazing land is significant and the implication of the analysis result is that grazing pasture is the major input for healthy livestock production. It refers to the availability of grazing land in required quantity and quality in nearby areas.

Livestock holding

The survey result shows that the average livestock owned by sample households excluding dairy cows are 5.61 TLU with a minimum and a maximum of 1.7 and 15.23 TLU, respectively. This shows that there is variability in terms of livestock ownership among the sample households. Livestock is an important component of the farming system, which is managed by the households, and it is an important asset for rural households and serves multiple purposes. It contributes draught power, manure, basic sources of cash income and consumption for the household. In general, the livestock holding is measured in terms of TLU or heads.

Breed type

Breed type may be local breed or crossbred. From a total sample household, 57.69% and 42.31% owned local and crossbred cows, respectively. This shows that a comparable amount of both types of breed exist in the study area. Marta (2012) reported that milk yields of crossbred cows averaged 3 times higher than that of the local cows in north Gonder.

4.1.3. Institutional Factors

Extension Service

This variable is treated as a continuous variable and measured by the number of visits made by the extension agents to sample households. The survey result indicates that the average number of extension contacts during the production season in relation with milk production were about 3.13 times with a standard deviations of 2.37, ranging from no contact to a maximum of 5 visits during the survey year. According to Babatunde (2007), the extension visits will help to reinforce the message and enhance the accuracy of implementation of the technology packages. Extension service is often provided by the development agents who have graduated from different colleges specializing in crop production, animal husbandry and natural resource management. The extension workers visit farm households at different intervals and provide an extension service that helps to enhance productivity. It is expected that households who have contacts with extension agents do get timely suggestions making themselves more efficient in the operation and milk production.

Proximity to the nearest market center

Survey result shows that households in the study area walk on average 4.29 kilometres with a standard deviation of 4.84 to reach the nearest market place. This indicates that households walk long distance to sell milk and their milk products and purchase inputs for dairy cows. The nearer a household resides to a market center, the higher he/she can sell milk and their milk products and purchase inputs such as salt, concentrate, dry fodder, etc. for dairy cows.

4.1.4. Milk Production

The existing farming system in Sululta area is a crop-livestock based farming system where animals are reared for supplying power to land cultivation and milk production. Milk production is predominantly a smallholder activity in the area under the mixed crop-livestock production system. The number of cows for milk production, by sampled households during the survey period in the study area was on average 2.41 lactating cows.

The average lactation period per cow during the 2015/16 production period in the study area was estimated to be about *six* months. Milk yield of indigenous cow ranges between 0.75 and 5 litres per day per cow and average milk yield was 1.72 litres per day per cow. On the other hand, per day per cow milk yield of crossbred cow ranged between 2.5 and 16 litres with an average milk yield of 8.5 litres. The average daily milk yield of crossbred cow was higher than that of an indigenous cow.

According to the interviewed heads of sample households they sell their milk and milk products to hotels, cooperatives, different milk processing industries, markets and neighbours to get cash income. Milk collection function is played by cooperatives that operate in the district and private milk processing plant collectors that operate travelling from Addis Ababa. Fresh milk is collected daily from the milk producer households during the morning times. Households who sell milk to different milk processing plants and cooperatives do supply milk daily on credit basis and they get paid every 14 days. Cooperatives and private milk processing plant collectors pay an average of Birr 9.35 per litre of milk.

4.1.5. Constraints of Milk Production

In the study area, the sample households reported that they faced many production constraints. It is important to note that multitudes of problems related to water scarcity, shortage of feed, lack of veterinary service, diseases and low productivity of the endogenous cattle breeds are the major factors limiting dairy productivity coupled with drought problem. The sample households walk long distance to drink their cows or fetch water for their dairy cows.

In the area there is a problem of feed shortage for milking cows, especially during dry season and households tackle the shortage through purchase from markets. The prevalence of various animal diseases, internal parasites and infectious diseases affect dairy cows. The animal health services provided are not sufficient; the costs of drugs are very high, while the diagnostic services are not readily available to the dairy producers. Depending on the number of total responses, the major problems affecting milk production in the study area were ranked to be water problem (42.3%) shortage of feed (38.5%) lack

of veterinary service (6.2%) disease (3.8%) and the remaining ones constituted 9.2%, in the study area.

Table 3. Major problems of milk production in the study area

Perceived Problems of milk production	Frequency	Percent
Water problems	55	42.3
Shortage of feed	50	38.5
Lack of veterinary service	8	6.2
Diseases	5	3.9
Others (such as drought, market, shelter, shortage of labor, lack of Vet service, etc.)	12	9.2

Source: Own computation result based on survey data of 2016.

The prices of crossbred dairy cows were very high as compared to local dairy cows to replace local breed cows with crossbred ones. Lack of artificial insemination technicians is also another worth mentioning constraint.

Data on animal feed practices of sample households in the study area was gathered to assess the feed utilization experience. Sample households were dependent on natural pasture and grazing areas, hay, crop residues from crop systems after harvest, improved feed and purchased concentrate. Feed types that are said to increase milk production in the area are concentrate and green fodder. Most of the households allow the animals free grazing and sometimes tethering system is also used. During the survey period the sample households were asked to mention the major problems with regard to the availability of concentrate feed for milking cows. In response they reported that concentrate is costly to purchase. Feed improvements used for dairy cows in the area are reported as water soaking with salt and hay.

4.1.6. Variables Used to Estimate the Production Function

The production function for this study was estimated using five input variables (the physical inputs employed in the production of milk output). Table 3 presents summary statistics of production variables.

The dependent variable in estimation of the production function is the milk output, measured in litres. The result of analysis for output variable indicates that, on average, a household produced 850.32 litre of milk with a standard deviation of 389.23 during the 2015/16 production year. The number of cows for milk production, by sampled households during the survey period was on average 2.41 with a standard deviation of 1.23. The number of cows owned by the sample households ranged between 1.00 and 4.00 minimum and maximum respectively. The other very important variable is labor measured in (man-days). The mean level of household labor used by milk producers in the study area was found to be 1709.31 man days per year with a standard deviation of 636.64 man days. This has been obtained by aggregating labor used for all milk production activities including feeding, milking, barn cleaning, watering, herding, taking care of sick animals, etc. at household level throughout the year.

Regarding, the feed types, the most commonly and intensively used feed for the dairy cows for the production of milk are green fodder, dry fodder and concentrate. The sample households used on average, 4925.58 kg of dry fodder with a standard deviation of 3015.12 kg. The summary result indicates that the mean green fodder used stands at 3354.22 kg ranging from 932.46 kg to 8762.19 kg. The result also indicated that average quantity of concentrate used by farmers was about 2698.67kg. The maximum and the minimum amount of concentrate feed used were 6265.31 kg and 941.27 kg, respectively with a standard deviation of 1614.59 kg.

Table 4. Descriptive statistics of both input and output variables

Variables	Statistical measures			
	Mean	St. Deviation	Min	Max
Continuous variables				
Output (litres)	850.32	389.23	221	2217
Cows (in number)	2.41	1.24	1	4
Labor (man-days)	1709.31	636.64	879.4	2571.11
Green fodder (kg)	3354.22	2413.47	932.78	8762.19
Dry fodder (kg)	4925.58	3015.12	1881	10991.8
Concentrate (kg)	2698.67	1614.59	941.27	6265.31

Source: own computation results based on survey data of 2016.

4.1.7. Variables Used to Estimate Efficiency or the Inefficiency effect Model

This part presents the review statistics of the explanatory variables that are anticipated to cause technical efficiency variation among milk producers in the study area. A total of 13 variables were hypothesized to affect efficiency of milk producers, out of which 2 of them were dummy variables. Table 4 illustrates summary of these variables.

Table 5. Variables used in the efficiency model analysis

Variables	Statistical measures			
1. Continuous variables	Mean	St. Deviation	Min	Max
Age (years)	45.37	16.27	27	79
Education (class years)	2.79	3.55	0	12
Total livestock holding (TLU)	5.61	4.96	1.70	15.23
Land holding (ha)	0.89	0.79	0	3
Availability of Grazing land (ha)	0.27	0.39	0	1.25
Off/non-farm income (Birr)	12953.85	28412.76	0	86000
Credit use (Birr)	553.85	2038.63	0	8000
Extension contacts (frequency)	3.13	2.37	0	5
Distance to veterinary clinic (km)	5.18	4.76	0.2	11
Proximity to the market (km)	4.29	4.84	0.1	11
Distance to water (km)	0.96	0.90	0.1	3.5
2. Dummy Variables	Response	Frequency	Percentage	
Breed type	Local (0)	75	57.69	
	Crossbred(1)	55	42.31	
Training	Trained (0)	71	54.62	
	Otherwise (1)	59	45.38	

Source: Own computation results based on survey data of 2016.

Table 4 portrays that the average age of sample household heads was 45.37 years ranging from 28 to 79 a minimum and maximum, respectively. The educational level of the household head, on average, was 2.79.

The result also indicates that an average number of livestock owned by sample households excluding dairy cows is 5.61 in TLU with a minimum and maximum of 1.7 and 15.23 TLU, respectively. The average annual number of visits made by extension agents was 3.13 days, from no visit to a maximum of 5 days in 2015/16 production year. The average income that households secured from off/nonfarm activities is 12953.85 Birr per year with a maximum of 86000 Birr during the production year 2015/16. The average amount of credit received by the sample households during the production year was 553.85 Birr for the purpose of milk production. The amount of credit received ranges between zero and a maximum of 8000 Birr.

The result also shows that the average veterinary clinic distance from residence has a mean value of 5.18 km, while the walking proximity to the nearest market has a mean value of 4.29 Km, with a standard deviation of 4.84 Km with a minimum of 0.1 km and a maximum of 11 Km. The average distance of water point from residence has a mean value of 0.96 Km with a standard deviation of 0.90 Km. The average land holding for crop production during the production year was 0.89 ha with a standard deviation of 0.79 ha ranging between zero and a maximum of 3 ha. The average grazing land for their dairy cows was 27 ha from do not own grazing land for their dairy cows to a maximum 1.25 ha during 2016 production year.

Finally, the survey result also shows that 57.69% of the sample households own local breed cows and 42.31% own crossbred cows ones. From the total sample households, 54.62% of them had an opportunity to participate in dairy production related training, while 45.38 percent did not have a luxury of being trained.

4.2. Econometric Results

This section presents the econometric model outputs of the study. In this section, the production function, efficiency scores and the determinants of efficiency differentials are presented and discussed.

4.2.1. Hypotheses Testing

One attractive feature of SPF method is that, it is possible to test various hypotheses using maximum likelihood test ratio. Therefore, before discussing about parameter estimates of production frontier function and the inefficiency effects, it is advisable to run hypotheses tests in order to choose an appropriate model for further analysis and interpretation. Tests of hypothesis for the parameters of the frontier model were conducted using the generalized likelihood ratio statistics, λ , defined as:

$$\lambda = -2[\log L(H_0) - \log L(H_1)]$$

Where, $L(H_0)$ and $L(H_1)$ are the values of the log-likelihood function under the null and alternative hypotheses, H_0 and H_1 , respectively. Tests of hypotheses for the parameters of the frontier model were conducted using the generalized likelihood ratio statistics, λ , defined by equation (12). Accordingly, the following hypotheses were tested, with a view to select the correct functional form for the given data set, to check the existence of inefficiency and finally to pinpoint variables that explain the difference in efficiency.

Table 6. Generalized likelihood ratio tests of hypothesis for the parameters of the SPF

Null Hypothesis	DF	LH_0	LH_1	Calculated	Critical	Decision
				$\chi^2(LR)$ Value	value ($\chi^2, 0.05$)	
$H_0: \beta_6 = \beta_7 = \dots = \beta_{20} = 0$	15	-16.14	-5.28	21.72	24.99	Accepted
$H_0: \gamma = 0$	1	-28.26	-16.14	24.24	3.84	Rejected
$H_0: U_i = \delta_1 = \delta_2 = \dots = \delta_{14} = 0$	14	-39.04	-16.14	45.80	23.68	Rejected

Source: Own computation results based on survey data of 2016.

The first test was the null hypothesis that identifies an appropriate functional form between restrictive Cobb Douglas and the non restrictive Translog production function which specifies that square and cross terms are equivalent to zero. The test result shows that the

accepted null hypothesis implies that the Cobb Douglas functional form best fit the data set (Table 5)

Similarly the second test was that the null hypothesis $H_0: \gamma = 0$, which specifies that the inefficiency effects in the SPF were not stochastic. The generalized likelihood ratio statistics, $\lambda = 24.24$, presented in Table 5 is found to be greater than the critical value of 3.84. The null hypothesis that the average response function is an adequate representation of the data can be rejected at 5% level of significance. Consequently, the null hypothesis that milk producers in the area are fully efficient is rejected. Hence there is a considerable inefficiency among sample households in the production of milk in the study area. Therefore the null hypothesis was rejected (Table 5). This implies that the traditional average production function does not adequately represent the data.

The last hypothesis test is the null hypothesis that the explanatory variables associated with technical inefficiency effects model are all zero, ($H_0: U_i = \delta_0 = \delta_1 = \delta_2 = \dots = \delta_{14} = 0$). To test this hypothesis likewise, λ was calculated using the value of the log likelihood function under the stochastic frontier model (a model without explanatory variables of inefficiency effects, H_0) and the full frontier model (a model with variables that are presumed to determine inefficiency of each household, H_1). The calculated value of $\lambda = 45.80$ which is greater than the critical value of 23.68. Thus the null hypothesis that variables in the inefficiency effects model are simultaneously equal to zero is rejected at 5% level of significance (Table 5). Therefore, the explanatory variables associated with inefficiency effects model are simultaneously different from zero. The clear implication is that, these variables explain the difference in inefficiency among households.

4.2.2. Parameter Estimates of the SPF Model

The stochastic production frontier model was specified and estimated using the Maximum Likelihood method to analyze the technical efficiency of sample households in the production of milk in Sululta district and a single step estimation procedure was used. The model comprises of twenty one parameters, five of which were the explanatory variables of the stochastic frontier function while 14 of which were, the explanatory variables that were

hypothesized to influence the technical efficiency scores and the remaining two being the parameters associated with the distribution of v_i and μ_i .

Technical efficiency was estimated using the selected functional form. The maximum likelihood estimation of the SPF with inefficiency model gives the individual and mean level of technical efficiency. The value of the parameter estimates of the inefficiency effects variables (μ_i) and the value of gamma (γ). The maximum likelihood estimates of the parameter of SPF functions together with the inefficiency effects model are presented in Table 6.

Table 7. Maximum-likelihood estimates of the Cobb-Douglas SPF with inefficiency model

Variables	Coefficients	Standard-error	t-ratio
Constant	1.51***	0.48	3.12
Cows (number)	0.40***	0.08	5.12
Dry fodder (kg)	0.39***	0.09	4.27
Concentrate (kg)	0.13**	0.06	2.25
Green fodder (Kg)	-0.01	0.06	-0.16
Labor (man-days)	0.18**	0.07	2.41
Inefficiency effect model			
Sigma-squared (σ^2)	0.28	0.05	
Gamma (γ)	0.91		
Log-likelihood function	-16.14		

Note: ** and *** significant at 5% and 1% significance level, respectively.

Source: Own computation results based on survey data of 2016.

The diagnostic statistics of inefficiency component reveals that sigma squared (σ^2) was statistically significant which indicates goodness of fit, and the correctness of the distributional form assumed for the composite error term. The estimated value of Gamma (γ) is 0.91 which indicates that 91% of total variation in milk output among sample farmers is due to technical inefficiency, while the remaining about 9% variation in milk output was due to the effect of out of the control of the farmers like weather, disease, and drought etc. This implies that, there is a room for improving output of milk by first identifying those institutional, socioeconomic and farm specific factors causing this variation.

Table 6 depicts that the estimated coefficients for the number of lactating cows, quantity of dry fodder, quantity of concentrate and quantity of labor used are all positive and significant at 1%, 1%, 5% and 5% respectively, which confirm that there was a positive relationship between the input used and output produced.

The coefficients of inputs indicate that on average a 1% increase in number of cows, dry fodder, concentrate and labor increases the output of milk by 0.40%, 0.39%, 0.13% and 0.18%, respectively.

Since the major concern of this study is to know the level of technical efficiency of milk producer households and the major factors determining the technical efficiency differentials in the study area, in-depth discussions on the structure of production function and coefficients of input variables will not be made. The maximum-likelihood parameter estimates of the model are used to predict the level of individual household's technical efficiency.

4.2.3. Technical Efficiency Scores

The mean TE of the sampled milk producer households in 2015/16 production year was 74%, with minimum and maximum efficiency levels of about 37% and 95%. This shows that there is a wide disparity among milk producer sample households in their level of technical efficiency, which may in turn indicate that, there exists a room for improving the existing level of milk production through enhancing the level of households' technical efficiency. The mean level of technical efficiency further tells us that the level of milk output of the sample households can be increased, on average, by about 26% if appropriate measures are taken. In other words, there is a possibility to increase milk production efficiency by about 26% using resources at their disposal in an efficient manner without introducing improved (external) inputs and technologies (Table 8).

Table 8. Estimates of technical efficiency scores of the sample households

Description	Technical efficiency estimates
Mean	0.74
Maximum	0.95
Minimum	0.37
Standard deviation	0.18

Source: Own computation results based on survey data of 2016.

4.2.4. Sources of Technical Inefficiency in Milk Production

The analysis of technical efficiency estimates revealed that there are significant technical efficiency differences among the dairy producing households as indicated in the previous section. Given a set of the existing technologies and inputs, some households were able to achieve higher technical efficiency in milk production while others were found inefficient. This divergence could be related to many factors. Therefore, it is important to identify factors which influence the technical efficiency of the dairy producers to further intervene and increase milk production in the study area. The parameters of the various hypothesized variables in the technical inefficiency effect model that were expected to determine efficiency differences among farmers were estimated through MLE method using a one-stage estimation procedure.

The determinants of technical inefficiency/efficiency in a given period vary considerably depending on the socio-economic conditions of the study area particularly pertaining to managerial characteristics and other related factors. Table 8 depicts the socioeconomic and institutional factors that affect efficiency in milk production. The result in the table is presented in terms of inefficiency and hence the negative sign shows the increase in the value of the variable attached to the coefficient meaning the variable negatively contributes to inefficiency level or conversely it contributes positively to efficiency levels. Thus any negative coefficient happens to reduce inefficiency which implies its positive effect in increasing or improving the efficiency of cow milk production and vice versa.

Out of the 14 variables considered, 8 variables (age, age-square, land ownership, availability of grazing land, total livestock holding, breed type, frequency of extension

contact and distance to market center) were found to significantly influence the inefficiency of milk producing households.

Table 9. Maximum likelihood estimates of the factors determining technical inefficiency

Variables	Coefficient	Standard-error	t-ratio
Constant	3.76***	1.42	2.64
Age (Years)	-0.14***	0.05	-2.63
Age ² (Years)	0.001**	0.001	2.00
Education (class years)	0.02	0.05	0.44
Total livestock holding (TLU)	-0.09**	0.04	-1.98
Land holding (ha)	0.41*	0.23	1.77
Availability of grazing land (ha)	-1.27***	0.47	-2.68
Breed type (1=crossbred, 0=local)	-1.04**	0.42	-2.50
Distance to veterinary clinics (km)	0.04	0.04	0.92
Proximity to the nearest market (km)	-0.07*	0.04	-1.82
Distance to water source (km)	-0.23	0.21	-1.12
Amount of credit (Birr)	0.04	0.03	1.22
Extension contact (frequency)	-0.17**	0.08	-2.16
Non/ off-farm income (Birr)	-0.01	0.03	-0.51
Training (1=trained, 0=otherwise)	0.13	0.39	0.32
Sigma-squared (σ^2)	0.28	0.05	
Gamma (γ)	0.91		
Log-likelihood function	-16.14		

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

Source: Own computation results based on survey data of 2016.

The technical inefficiency factors estimated and presented in Table 8 depicts that age, age-square, total livestock holding, land for crop production, availability of private grazing land, breed type, Proximity to nearest market center and frequency of extension contact are found to be statistically significant determinants of technical inefficiency.

Age changes the general farming experience and physical capacity of farmers, which in turn bring differences in abilities of decision making and laborious farming practices. It was hypothesized that as the age of the farmer increases, he will be able to use resources in such a way that yields the maximum possible output. However, this may diminish, as the household head gets older. The result shows that the age and age-square have negative and positive signs, respectively and both are significant. Thus, middle age farmers are more efficient than the very young and older ones. Since dairying as any other professions needs accumulated knowledge, skill and physical capability, it is decisive in determining efficiency. The knowledge, the skills as well as the physical capability of heads of households is likely to increase as their age increases. However this tends to decrease after a certain age level.

To compare the existence of technical efficiency differential among different age groups, sample farmers were arbitrarily classified in to three age groups. The assumption was that farmers within the age range of above 55 are older and lack the capacity to work energetically even if they have good experience in farming. Farmers below the age of 30 also lack experience and motivation towards farming. On the other hand, farmers of the middle age group (30-55) are relatively more energetic to work than the older farmers and have relatively more experience and motivation to engage in farming than the youngsters. The mean level of technical efficiency for the lower, middle and older farmers of the study area was 68.89, 84.12 and 70.03 percent, respectively. It can be seen that the average efficiency level of middle age household heads is greater than the other age groups. But this is not significantly different because the grouping of age as shown below is arbitrary. However, the quadratic regression of age with technical efficiency level shows that the efficiency level diminishes, as age of the farmer gets older after a certain level of age.

Table 10. Age of households and mean level of technical efficiency

Age group	Frequency	Mean TE	Standard deviation
<30	27	68.89	16.50
30-55	64	84.12	15.54
>55	39	70.03	18.08

Source: Own computation results based on survey data of 2016.

The positive relationship of age and efficiency obtained in the study is consistent with the findings reported by Bardhan and Sharma (2013), Lemma *et al.* (2013) and Masunda and chiweshe (2015).

Total livestock holding is a total number of livestock owned by a household excluding dairy cows and treated as a continuous variable measured in Tropical Livestock Unit. Livestock enterprise in a mixed crop-livestock farming system have two fold importance in that it supplies oxen power for threshing, provide draught power and are sources of food and income for the family. The coefficient of this variable is negative and statistically significant implying that households who had better livestock holding were technically more efficient in milk production than others. The possible explanation is that large livestock owners are more likely to be risk takers, technology adopters, have easy access to credit, training and technical support. This result is in agreement with the findings of Tauer (2001), Demircan *et al.* (2010) and Nakanwagi and Hyuha (2015).

Proximity to the nearest market center is the distance that the households walk to reach the nearest market center for the purpose of selling their milk and milk products and buying inputs for their dairy cows. The effect of walking distance to the nearest market center on technical inefficiency is found to be statistically significant and affects technical inefficiency negatively. This implies that households who reside far from markets are more technically inefficient compared to their counterparts who reside nearby markets. Based on this result, one can safely conclude that household who are located far from market have limited access to input and output markets and market information. Moreover, distance to market leads to higher transaction cost which reduces the benefits accrued to the households or vice versa. More importantly, longer distance from market center discourages producers from participating in market oriented production. Thus, development of market and road infrastructure could reduce resource use inefficiency and increase productivity of milk producers through facilitating market participation and integration. This finding is in line with what has been reported by Zewdie *et al.* (2015) and Teshager *et al.* (2013).

Land holding is a total land owned by sample household for crop production purpose during 2016/15 production year and treated as a continuous variable measured in hectare. According to Klie *et al.* (1997), larger the total area of the cultivated land the farmer owns,

the higher would be the output (grain and by product) and as a result higher income. As the cultivated land size increases, dairy cows holder gets more by product of cereal production (straw of barley, wheat and Teff, etc) to feed their cows. Households who have large cultivated land size can have a better option to diversify and to increase by product production he/she gets from main production. So, such a household will be in a better position to engage in milk production easily and efficiently. The sign is not as expected, the sign of land holding was positive and statistically significant in inefficiency of milk production in study area implying that households those have land for crop production were not technically efficient than those not have land for crop production. The finding is incongruence with the reports of Blata (2010), Tschopp *et al.* (2010) and Mosisa (2014).

Availability of grazing land is hypothesized to have positive impact on the efficiency of milk production in the study area. As expected, the coefficient of grazing land was negative and statistically significant in inefficiency of milk production, which implies that farmers who had grazing land were more efficient in milk production than not have grazing land. Ethiopian smallholder farmers mainly depend on green pasture measured in this paper in terms of availability of grazing land per household to graze their dairy animals. According to Derib (2010) the relationship between livestock income and availability of grazing land is significant and the implication of the analysis result is that grazing fodder is the major input for healthy livestock production. It refers to the availability of grazing land in required quantity and quality in nearby areas. The result is consistent with the studies of Zelalem *et al.* (2011) and Masuku (2014).

Breed type may be local breed or crossbred and considered as a dummy variable taking a value of zero for local cows and 1 for improved (50% Holstein Friesian crosses) breed. Schultz (1964) argued that adoption of new technologies enhances farm output, income and efficiency of the agricultural production. Marta (2012) reported that milk yields of crossbred cows averaged 3 times higher than of local cows in north Gonder. In line with this, Dayanadan (2011) also concluded in his finding and advised Mekelle town dairy cow's owners to replace their indigenous cows with crossbred ones. As can be seen from Table 8 breed type had a significant and negative effect on technical inefficiency of milk production in the study area. This implies that a household that uses at least one improved cow for milk production had higher technical efficiency than a household which

was relying only on local cows for milk production. This result is in line with the studies of Mosisa (2014), Mor and Sharma (2013), Zewdie *et al.* (2015) and Nakanwagi *et al.* (2015).

Finally, the model result shows that extension contact determines the inefficiency level of households negatively and significantly. This implies that farm households with increased frequency of contact with extension workers tend to be more efficient than their counterparts. This can be attributed to the fact that the knowledge gained from contact with extension agents could have influenced the milk producers to adopt improved technologies and management practices leading to an improvement in efficiency. Extension workers also should disseminate information about optimal input use, and consult directly with households on specific production problems, thus facilitating a shift to more efficient methods of milk production. This implies that the ongoing extension advisory service (mainly focused on methods of milk production) is bringing positive changes. This result is consistent with works of Lamma *et al.* (2013), Al-Sharafat (2013) and Ullah (2016).

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter deals with summary, conclusion and recommendation suggested based on the findings of the study.

5.1. Summary and Conclusions

This study was undertaken with the objective of assessing the technical efficiency of smallholder households of milk producers in Sululta district. Stochastic frontier model with inefficiency effects was used for analyzing cross sectional data obtained from 130 milk producers sample households in 2015/16 production year.

The Cobb-Douglas stochastic production frontier model with inefficiency effects was used to analyze the level of technical efficiency of the households with respect to milk production and the causes of technical efficiency differentials among the milk producers households of the study area. On the other hand, various farm household specific socio-economic and institutional variables that are expected to determine the technical inefficiency of milk households' were estimated simultaneously with the stochastic frontier model (one stage estimation procedure).

The estimated stochastic frontier Cobb-Douglas production function indicates that the number of lactating cow, quantity of concentrate, quantity of dry fodder and labor used for milk production were positive and significant determinants of production level. The positive coefficient of these parameters indicates that increased use of these inputs increasing the production level. Hence, given that these inputs are used to their maximum potential, introduction and dissemination of these inputs will increase the production level of milk in the study area.

The test result indicates that the traditional average response function is not an adequate representation of production frontier. This indicates that significant proportion of the variation in the stochastic frontier production function being due to technical inefficiency.

The computed average technical efficiency was 74%, ranging from a minimum of 37% to a maximum of 95%. This indicates that based on best practice, inefficient households can still increase their output by 26%. The wide variation in technical efficiency indicates that there exist substantial inefficiency in resource use among milk producers and there still exist opportunities for rising milk production by improving their current level of technical efficiency.

The generalized likelihood-ratio test proved that variables considered in the inefficiency effects model simultaneously explained the existing technical efficiency differences among households.

The estimated SPF model together with the inefficiency parameters show that age, total livestock holding, availability of grazing land, breed type, proximity to the nearest market center and extension contact have negative and significant influence on the inefficiency of milk producer households. However, the sign of the coefficients of age-square, and land holding for crop production have negative and significant influence on the inefficiency of milk producer households.

5.2. Recommendations

The result of the analysis showed that milk producers in the study area are not operating at full technical efficiencies levels. In addition, number of cows, dry fodder, concentrate and labor used in milk production were not efficiently utilized, meaning that opportunities still exist to increase output by proper utilization of these inputs.

Contrary to this, the green fodder input is over utilized in the study area. That means a unit increase in green fodder result in a reduced the milk production by the magnitude that is equal to its coefficient. The result also indicated that there is ample opportunity for milk producers to increase output at existing levels of inputs with present technologies available at the hand of producers.

Therefore, based on the results of the study the following policy recommendations have been suggested to improve milk production efficiency and productivity in the area.

First, the result of the study revealed that age and age-square had a negative and positive correlation with technical efficiency of milk production of the area simultaneously. This implies that households who are in the middle age group are relatively more efficient in the production of milk. In this regard experience sharing with those middle age group and relatively efficient households could help to improve the level of efficiency; especially for the youngsters.

Thus government policy in cow milk production should focus on ways to attract and encourage middle age people who are agile and aggressive in dairy business. This group of people would be able to put in a lot of efforts at raising the current level of efficiency, given a conducive policy environment.

Second, the positive relation of number of livestock owned by farmers to efficiency of milk production indicates that, households should increase the number of livestock they owned. This also implies governments and practitioners design strategies to integrate smallholder livestock and milk production and strengthen the linkage so as to further improve the milk production efficiency in the study area.

Third, breed type of dairy cow owned by households is positive and significantly affected technical efficiency of milk producers' households indicates that, households should change local breed they owned. This also implies governments and practitioners also design strategies to improve smallholder local breed owners by artificial insemination or supplying cross breed cows by lower purchasing price for households, so as to further improve the milk production efficiency of the households of the area.

Fourth, the result of the study reveals that farm households who have extension contact were more efficient than farm households without extension contact. Households with no extension contact can improve their performance level at least to be as technically efficient as those who have contact with extension workers. Hence, government should design and implement policy and strategy to increase extension contact rendering necessary advisory service to farm households which can help to increase household level of technical efficiency of milk production of the area. This could be done by designing appropriate capacity building program to train additional development agents to reduce the existing

higher ratio of household to development agents as well as to provide refreshment training for development agents.

Fifth, the result revealed that land for crop production and land for grazing had a negative and positive correlation with technical efficiency simultaneously. This shows that if we increase land for crop production means, we are on the other way of reducing land for grazing. So, policies and strategies should consider the expansion of crop land versus reduction of grazing land or train farmers on how to utilize the available grazing land efficiently and plant highly nutritive grass (fodder) to increase milk production.

Finally, households walking long distance to reach nearest market center are less efficient than their counterparts walking short distance to reach nearest market center for the purpose of selling their milk and milk products and buying inputs for their dairy cows. This implies that there is a need to improve or development of market, road infrastructure, and decision making process of farmers' institutions could reduce resource use inefficiency and increase productivity. These also reduce transaction cost and improve productivity, hence encourage households to participate in high value and market oriented production activities that enhance milk production efficiency of the area.

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7. APPENDICES

Appendix 1: Conversion factor to calculate man equivalent

Age group (years)	Man Days (MD)	
	Male	Female
<10	0	0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1.0	0.8
>50	0.7	0.5

Source: Storck *et al.* (1991) as cited in Dawit (2013)

Appendix 2: Conversion factor used to estimate Tropical Livestock Unit equivalents

Animal category	TLU
Calf	0.25
Weaned calf	0.34
Heifer	0.75
Cow and ox	1.00
Horse	1.10
Donkey (adult)	0.70
Donkey (young)	0.35
Camel	1.25
Sheep and goat (adult)	0.13
Sheep and goat (young)	0.06
Chick	0.013

Source: Storck *et al.* (1991) as cited in Dawit (2013)

Appendix 3: Estimated level of households technical efficiency

Firm	TE	Firm	TE	Firm	TE	Firm	TE	Firm	TE
1.	0.39	27.	0.41	53.	0.91	79.	0.90	105.	0.72
2.	0.81	28.	0.49	54.	0.93	80.	0.41	106.	0.59
3.	0.93	29.	0.71	55.	0.93	81.	0.38	107.	0.95
4.	0.77	30.	0.53	56.	0.82	82.	0.58	108.	0.57
5.	0.76	31.	0.78	57.	0.57	83.	0.78	109.	0.40
7.	0.85	32.	0.55	58.	0.81	84.	0.85	110.	0.63
6.	0.94	33.	0.51	59.	0.76	85.	0.51	111.	0.40
8.	0.42	34.	0.87	60.	0.88	86.	0.94	112.	0.80
9.	0.87	35.	0.51	61.	0.47	87.	0.87	113.	0.49
10.	0.45	36.	0.94	62.	0.83	88.	0.83	114.	0.89
11.	0.64	37.	0.94	63.	0.61	89.	0.92	115.	0.80
12.	0.42	38.	0.48	64.	0.89	90.	0.84	116.	0.93
13.	0.37	39.	0.95	65.	0.84	91.	0.79	117.	0.52
14.	0.94	40.	0.51	66.	0.94	92.	0.84	118.	0.95
15.	0.94	41.	0.49	67.	0.60	93.	0.79	119.	0.77
16.	0.84	42.	0.44	68.	0.79	94.	0.77	120.	0.82
17.	0.60	43.	0.78	69.	0.50	95.	0.60	121.	0.73
18.	0.59	44.	0.91	70.	0.84	96.	0.85	122.	0.93
19.	0.68	45.	0.89	71.	0.78	97.	0.52	123.	0.85
20.	0.75	46.	0.94	72.	0.68	98.	0.89	124.	0.89
21.	0.54	47.	0.58	73.	0.90	99.	0.92	125.	0.79
22.	0.55	48.	0.93	74.	0.93	100.	0.71	126.	0.44
23.	0.38	49.	0.86	75.	0.82	101.	0.90	127.	0.77
24.	0.85	50.	0.93	76.	0.93	102.	0.90	128.	0.60
25.	0.94	51.	0.89	77.	0.91	103.	0.57	129.	0.81
26.	0.69	52.	0.86	78.	0.92	104.	0.92	130.	0.61

Source: Own computation results based on survey data of 2016.

Questionnaire developed for the study

Forms and Questionnaires developed for analysis of Technical Efficiency of Milk Production in Sululta district

Name of the enumerator.....

Signature date.....

1. Household characteristics

1.1. Name of *Kebele* Administration.....Name of the village.....

1.2. Name of household head..... Age.....

1.3. Sex of the household head 1. Female 2. Male

1.4. Dairy production experience in years.....

1.5. Level of education? 1. Illiterate 2. Read and write 3. Formal year of schooling
highest grade you completed.....

1.6. Total household size (including extended family members).....

1.7. House hold characteristics; relationship with the household, sex, age, educational level
of household member and responsibility in the household.

No .	Name of the family members excluding household head	Relationship with the HH head (X)	Sex 1)Male 2)Female	Age	Formal Education al level in years	Responsibility in the household (Y)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

NB: (X) = 1) Wife 2) husband 3) Son 4) Daughter 5) Mother 6) Others

Y) = 1) full time working on family farm 2) Half time work on family farm

- 3) Organizing supervising farm activities 4) Food preparation and Supply
- 5) Participate on nonfarm activities 6) Keeping and herding cattle
- 7) Others specify.....

- 1.8. Religion of the household head 1. Orthodox 2. Muslim/Islamic 3. Protestant
4. Others
- 1.9. Marital status 1. Married 2. Single 3. Divorced 4. Widowed

2. Farm characteristics

- 2.1. Total Land holding in local units of measurement.....
- 2.2. Do you have land for Crop activities? 1. No 2. Yes
- 2.3. If yes (in no. 2.2), how many of hectares allocated for crop production?.....ha
- 2.4. Do you have private land for grazing 1. No 2. Yes
- 2.5. If you have private land for grazing, how many in hectares?.....ha
- 2.6. Which season is the most important for dairying activities?
1. Summer 2. Autumn 3. Winter 4. Spring
5. Whole year
- 2.7. What is your reason for the season elected?.....

2. Responsibility

- 3.1. Do you have any responsibility in the society? 1. Yes 2. No
- 3.2. If yes, what is your responsibility in the society? 1. Management body of the KA 2. Political cadres 3. Militant 4. Management body of other social organization (cooperative, *Edir*, *Ekub*, religion, etc) 5. Other (specify).....
- 3.3. Does your responsibility have significant impact on performing dairying?
1. Yes 2. No
- 3.4. If your answer for question number 3.3 is yes, what impacts does your responsibility have?
1. Positive 2. Negative
- 3.5. How many days on average do you spend per week on your additional responsibility?
1. One day 2. Two day 3. Three day 4. Four day

No.	Type of crops	Area allocated (ha)	Grain yield per hectare (kg)	By product per hectare (kg)	Remark
1					
2					
3					
4					
5					

3.6. Who take care of the dairying activities while performing your additional social responsibility?

1. Family members 2. Hired workers 3. Relatives 4. The society
5. Others (specify).....

4. Type of cereal crop produced by household

4.1 Are you growing crops in 2015/16? 1) No 2) Yes

4.2. If yes (in question no 4.1), major crops grown in (2015/16) production season

5. Type of animal owned

5.1. Do you have cattle other than dairy cows? 1) No 2) Yes

5.2. If yes, the type and number of cattle owned by farmer in 2015/16

No.	Type of animal	Number		Approximate value in birr	Remark
		Owned	Not owned		
1	Oxen				
2	Heifer				
3	Bull				
4	Not milking cow				
5	Calves (not weaned)				
6	Calves weaned				
7	Donkey (adult)				
8	Donkey (young)				
9	Mule				
10	Sheep (adult)				
11	Sheep (young)				
12	Goats (adult)				
13	Goats (young)				
14	Chickens				
15	Horse				
16	Beehives				
	1) Modern 2) Local				

6. Information on milk production

6. Do have crossbreed dairy cows? 1. No 2. Yes

6.1. If you have cross breed cows, from where you get them?

1. Research centers 2. NGOs 3. Market 4. Sululta district
agricultural office 5. Others (specify).....

6.2. If you don't have cross breed cows, why?

6.3. Why do you keep cows? 1. For milk production 2. For resale 3. For
breeding 4. All 5. Others (specify).....

6.4. Most of the time where do you graze/feed your cows? 1. Own grazing land 2.
Communal land 3. Purchased agro byproducts 4. Purchased forage 5. Own by
product 6. Own forage 7. Own agro byproducts 8) others

6.5. How often do you water your cows in rainy season? 1. Twice/day 2. Once/ day
3. Once/two days 4. Three times/week 5. Others (specify).....

6.6. How often do you water your cows in dry season? 1. Twice/day 2. Once/
day 3. Three times/week 4. Other (specify).....

6.7. How far of water sources (river) for your cows from your home (km and minutes)
.....and.....

6.8. Do you think that the distance having significant effect on milk production?

1. Yes 2. No

6.9. If yes (in question no 6.8), what kind of problem.....

.....

6.10. Did you give feed supplement for your milk cows apart from natural grazing?

1. No 2. Yes

6.11. If your answer for question number 6.10 is yes, which type frequently supplied to milk
cows on average per day in 2015/16?

Type of feed	Measurement unit(in kg, <i>ba'aa</i> , <i>kuntaala</i> or in litters)	Unit Price		Sources you obtain	
1.Dry fodder		1	2	market	own land (Production)
✓ Wheat straw					
✓ Barley straw					
✓ Maize stalk					
✓ <i>Teff</i> straw					
✓ Pea straw					
✓ Bean straw					
✓ Other					
2.Green fodder					
✓ Alfalfa					
✓ Napier grass					
✓ Other					
3.Concentrate					
✓ Noug cake					
✓ Linseed cake					
✓ processed and brewed drinks					
✓ Salt					
4.others					

1. Local dairy cows

2. Cross breeds

6.12. What are the major problems in availability concentrate feed for milk cows?

1. Unawareness 2. Distance 3. Costly 4. Combination of them

5) Others (specify)

6.13. Which type of feed do you think relatively increase milk production?

1. Dry fodder 2. Green fodder 3. Concentrate 4. Others

(specify)

6.14. What types of feeding system you used for your dairy cows?

1. Freely grazing 2. Cut and Carry / stall feeding 3. Tethering

4. Others (specify)

6.15. What type of feed improvement/treatment you used for your dairy cow?

1. Urea treatment 2. Chopping 3. Water soaking with salt 4. Silage making

5) Hay 6. No treatment

6.16. What type of feed conservation/storage practices you used for dairy cow? 1. Pile at

home with shed; 2. Pile at home without shed; 3. Pile at farm without shed; 4. Pile at farm with shed 5. Left over the field

6.17. Is there a problem of feed shortage for milk cows? 1. Yes 2. No

6.18. If yes (in question no 6.17), when and what

6.19. If yes (in question no 6.17), how do you manage the shortage of feed?

6.20. What type of dairy cows you have? 1. cross-breed 2. Local

3. Both

6.21. How many cows give milk at a moment in 2015/16?

1. Cross..... 2. Local

6.22. Is milk yield per cow the same over last 5 years? 1. Yes 2. No

A. Increased

B. decreased

6.23. Why is the reason?.....

6.24. How many times do you milking your cows in a day?

1. Once 2. Twice 3. Three times 4. Others (specify)

10.25. For how many months did you milk your cows before they dry out?

i) Local cows

1.6 months 2.7 months 3.8 months 4.9 and above months

ii) Hybrid cows

1.6 months 2.7 months 3.8 months 4.9 and above months

10.26. What is the average amount of milk produced in 2015/16 at household level per day in litters?

Type of production	Total number of milking cows	Total production in L							Maximum selling price(birr/L)	Minimum selling price(birr/L)
		S	M	T	W	Th	F	S		
Local										
Hybrid										

6.28. Do you provide preferential treatment to the cross breed than local dairy cows?

1. No

2. Yes

6.29. If yes (in question no 6.25),

1. By providing additional feed 2. By providing better shelter 3. By providing especial care in terms of veterinary services 4. I don't have cross bred cows

5. Others (specify).....

6.31. The main purpose of the milk produced? 1. Sale only 2. Household

consumption only 3. Sale and consumption

4. Others (specify).....

6.32. If some amount of milk sold, how much in last year?.....Liters

6.33. How far of market from your home for selling your milk?.....km

10.34. How long does it take to dispose of cow's milk for sale after milking?

1. <1 hours

2. 1-2hours

3. 2- 4 hours

4. 5 and

above

6.35. How the markets demand for your milk? 1. Strong 2. Moderate 3. Weak

4. No demand

6.36. Who is your customer for the milk sold? 1. Neighbors 2. Retailers

3. Cooperatives 4. Hotel 5. Others (specify).....

6.37. What is the price you have sold one liter of cow milk on average?.....birr

6.38. Are you satisfied with the price? 1. No

2. Yes

6.39. If no, Why and what it should be?.....

6.40. What is the area of your barn in meter square (m²)?

6.41. How frequently you clean the barn?

1. Three times a day

2. Two times a day

3. Once a day

4. Others

(specify).....

6.42. What disease you have noticed in your herds of cows in 2015/16?

1. Mastitis

2. Trypanosomiasis

3. Brucellosis

4. Udder injury

5. Lump skin

6. Others

(specify).....

6.43. Where do you treat your cows when they are sick?

1. Government clinic

2. Private clinic

3. Using traditional herbs

5. Other

(specify).....

6.44. How far is government Vet. Clinic from homestead in kilometers?.....

6.45. Is there any problem on milk production concerning the distance of vet. clinic

1. Yes

2. No

6.46. If yes (in question no.6.44), what kind of problem and how should be solved as you think?

Problems.....

Ways it should be solved.....

6.47. Labor division at household level in dairy cow management in 2015 /16

[illegible]

8.3. If you have borrowed,

No	For what purpose	The amount in birr
1	Dairy improvement (AI, Vet. clinic, feed)	
2	Crop production	
3	Trading and other activities	
4	Others	

8.4. What the impact of the borrowed money has? 1. Positive 2. Negative 3. No impact

8.5. What is the reason if your answer is positive/negative?.....

8.6. Of the total money borrowed, how much was repaid?.....birr

9. Extension service and training

9.1. Did you have access extension contact in relation to livestock extension service in the year 2015/16? 1. N 2. Yes

9.2. If yes your answer for question 9.1 how often the extension agent contacted you specifically for livestock production and dairy product purpose within the twelve months?

1. Weekly 2. Two times monthly 3. Three times monthly
4. Monthly 5. Others (specify).....

9.3. Where did you meet with DAs 1. At their office only 2. At your farm only?
3. Meeting place only 4. Sometimes at office and sometimes at farm

9.4. If yes, what type of extension services did you get in relation to livestock and milk production?

1. Livestock production and management 4. Livestock health
2. Livestock feed production & management 5. Artificial insemination
3. Dairy production and Marketing 6. Others (specify).....

9.4. What kind of advice you got from DAs? 1. Livestock feeding system (mixing)
2. Milking system (quality) 3. Milk marketing 4. Others....

9.5. How many days did he/she come to see you in 2015/16.....days?

9.6. Did you get any practical training concerning dairy production over the last three years?

1. No 2. Yes

9.7. If yes (in question no 9.5), from which organization? 1. Gov't 2. NGO
4. Other (specify).....

9.8. If yes (in question no 9.5), on what activity you have trained?.....

9.9. For how many days you have trained?.....days