St. MARRY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

INSTITUTE OF AGRICULTURE AND DEVELOPMENT STUDIES
DEPARTMENT OF AGRICULTURAL ECONOMICS

TECHNICAL EFFIEIENCY OF COMMERCIAL DAIRY FARMS; THE CASE OF SULULTA DISTRICT, OROMIA REGIONAL STATE OF ETHIOPIA

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JUNE, 2017
ADDIS ABABA, ETHIOPIA

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A THESIS SUBMITTED TO St. MARRY'S UNIVERSITY
SCHOOL OF GRADUATE STUDIES
INSTITUTE OF AGRICULTURE AND DEVELOPMENT STUDIES
DEPARTMENT OF AGRICULTURAL ECONOMICS

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR MASTER OF SCIENCE DEGREE IN AGRICULTURAL ECONOMICS

BY;
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JUNE, 2017
ADDIS ABABA, ETHIOPIA

THE BOARD OF EXAMINERS

As members of the examining board of the final M.Sc. thesis open defense, we certify that we have read and evaluated the thesis prepared by Mekdes Gezahegn Debela, entitled "TECHNICAL EFFIEIENCY OF COMMERCIAL DAIRY FARMS; THE CASE OF SULULTA DISTRICT, OROMIA REGIONAL STATE OF ETHIOPIA" and recommend that it to be accepted as fulfilling the thesis requirement for Master of Science degree in Agricultural Economics.

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DECLARATION

I hereby declare that this thesis entitled “TECHNICAL EFFIEIENCY OF COMMERCIAL DAIRY FARMS; THE CASE OF SULULTA DISTRICT, OROMIA REGIONAL STATE OF ETHIOPIA” has been written by me and it is a record of my own research work. No part of this work has been presented in any previous application for another degree or diploma at any institution. All borrowed ideas have been duly acknowledged in the text and a list of references provided.

Mekdes Gezahegn Debela

JUNE, 2017

Addis Ababa, Ethiopia

ENDORSEMENT

This thesis has been submitted to St. Mary's University, School of Graduate Studies for examination with my approval as a university advisor.

Wondemagegn Chekol (PhD.) ___________________

Advisor **Signature**

May, 2017

Addis Ababa, Ethiopia

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ACKNOWLEDGEMENT

I would like to thank Wondimagegn Chekol (PhD), my advisor, for his encouragement, suggestions, guidance and overall assistance. Successful accomplishment of this research would have been very difficult without his generous time devotion from the early work of the thesis to its final write-up by adding valuable, constructive and ever teaching comments and thus I am indebted to him for his kind and tireless efforts that enabled me to finalize the study.

ACRONYMS

APRC	Animal Production Research Centre
AE	Allocative Efficiency
AI	Artificial Insemination
SOFED	Sululta Office of Finance and Economic Development
DA	Development Agents
DEA	Data Envelopment Analysis
EE	Economic Efficiency
FAO	Food and Agriculture Organization of the United Nations
GLR	Generalized Likelihood Ratio
HF	Holstein Friesian
IFPRI	International Food Policy Research Institute
IID	Independently and Identically Distributed
Ln	Natural Logarithm
LR	Likelihood Ratio
MLE	Maximum Likelihood Estimation
MARD	Ministry of Agriculture and Rural Development
MLE	Maximum Likelihood Estimate
MoARD	Ministry of Agriculture and Rural Development
OLS	Ordinary Least Square
SPF	Stochastic Production Frontier
TE	Technical Efficiency
VIF	Variance Inflation Factor

ABSTRACT

The study was conducted in Sululta district of Oromia Special Zone Surrounding Finfinne with specific objectives of estimating the technical efficiency of commercial dairy farms in the district and identifying factors associated with technical inefficiency. A total of 46 sample commercial dairy farms from six kebeles of the district were interviewed to collect the data. The study used both primary and secondary data. The study examined the technical efficiency of 46 commercial dairy farms in Sululta district by using a stochastic frontier production function approach. The study utilized cross-sectional data collected during 2015/16 production season. The result indicated that the dairy farm's mean technical efficiency of was 69%, suggesting sizeable technical inefficiency in milk production. The study further indicated that there was a significant inefficiency in milk production in the study area. The relative performance of each farm to the average milk production in the study area ranged from a minimum of 0.40% to the maximum of 0.90%, implying technical efficiency in milk production in the study area could be increased through better use of existing resources, given the current level of technology. The empirical result also showed that the variable with the highest effect on production is the number of lactating cows in the farm followed by herd costs, wealth (capital), and farm size and feed costs. Contrary to this, overhead cost affected TE negatively. It was found that a unit increase in overhead cost would result in a 0.164 unit reduction in milk production. With regard to the inefficiency model, the study revealed the negative coefficient of breeding method, feeding method, milking method; housing system and experience implying that these variables affect the level of efficiency positively. Of these variables, milking method and housing system found to be insignificant. On the contrary, the positive sign of milking frequency shows that these variables will affect the efficiency level negatively and significantly.

Key words; stochastic production frontier, technical efficiency, milk production.

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Ethiopia is reported to be endowed with the largest livestock population in Africa. According to CSA (2010) the cattle population was estimated at about 50.9 million. The indigenous breeds accounted for 99.19 percent, while the hybrids and pure exotic breeds were represented by 0.72 and 0.09 percent, respectively. From the total cattle population, 45.13 percent were males and 54.87 percent females. This indicates the importance of male cattle particularly oxen for draft power. However, in the crop/livestock mixed farming system, oxen work for a maximum of 100 days in a year. This means that for the rest of the year oxen compete for the meager feed resources though unproductive. An appropriate alternative strategy needs therefore to be put in place to reserve the feed for dairy cows that produce not only milk but also replacement stock. The total estimated goat population was about 22 million with indigenous breeds accounting for 99.98 percent and hybrid and pure exotic breeds for about 0.02 percent. The male and female goat population accounted for 30.83 and 69.17 percent, respectively. The total camel population was estimated to be 807 581 with the proportion of male and female camels being 33.88 and 66.12 percent, respectively (CSA, 2010a).

In spite of such a substantial potential, the dairy sector is not developed to the expected level. The annual growth rate in milk production of 1.2 percent falls behind the annual human population growth estimated at 3 percent (GRM International BV, 2007). The traditional milk production system, which is dominated by indigenous breeds of low genetic potential for milk production, accounts for about 97 percent of the country's total annual milk production (Felleke, 2003). The low productivity of the country's livestock production system in general and the traditional sector in particular is mainly attributed to shortage of crossbreed dairy cows, lack of capital by dairy producers, inadequate animal feed resources both in terms of quality and quantity, unimproved animal husbandry systems, inefficient and inadequate milk processing materials and methods, low milk production and supply to milk processing centers and poor marketing and market information systems.

On the other hand, the large livestock population, the favorable climate for improved, high yielding animal breeds and the relatively disease-free environment for livestock make Ethiopia to have a significant potential for dairy development. Considering the important prospective for smallholder income generation and employment opportunities from the high value dairy products, the development of the dairy sector can contribute immensely to poverty alleviation and improved nutrition in the country. With the present trend characterized by transition towards a market-oriented economy, the dairy sector appears to be moving towards a takeoff stage. Liberalized markets, involvement of the private sector and promotion of smallholder dairy are the main features of this stage (Ahmed et al., 2004).

Putting in place a functional quality control system is an important tool to bring about improvement in the dairy sector. However, the country has no properly operational formal marketing and grading system that is geared towards matching the quality of milk and milk products to market prices. Identification of formal markets that demand standard and high quality products will help to determine market prices based on the quality and thereby enhance commercialization of the smallholder dairy sector. The approach provides an incentive for farmers to produce milk and milk products of good quality from the nutritional as well as the consumers' health perspective. This approach of availing a formal market with a price related grading system for milk has been demonstrated to be successful in many countries.

Agriculture continues to be the main stay of the Ethiopian economy given its significant contribution towards Gross Domestic Product (GDP) and employment. Besides, it is the main source of foreign currency, employment as well as agro-industrial raw material. However, Ethiopia's agricultural sector is known for its low productivity. One way of increasing productivity is through improving efficiency (Farrell 1957). The efficiency gains thus obtained could lead to resource savings that can be put into alternative uses (Bravo-Ureta and Rieger 1991).

The implication is that to bring about desirable changes in agriculture, it is important to focus on introducing new technologies as well as increasing efficiency. In poor countries such as Ethiopia where options for new technology introduction and resource expansion are few, identifying the extent and sources of inefficiencies in production given the existing technology and input are crucial and relevant policy issues.

Dairy plays an important role in the Ethiopian agricultural sector and the national economy (Tegegne et al. 2013). The sector is a source of livelihoods for a vast majority of the rural population in terms of consumption, income and employment. Recent estimates by the nation's Central Statistical Agency (CSA) indicate that there are about 55 million cattle, of which 44.6% are male and 55.4% are female (CSA 2014). The CSA survey further indicates that 2.8 billion liters of milk was produced in 2012/2013.

1.2. Statement of the Problem

According to FAO statistics (2014), over the period 1993 to 2012 total annual milk production have been growing, but at a moderately slow rate. Mohamed et al (2004) attributed the growth mainly to technological interventions and policy reforms. However, Nathaniel et al (2014) argue that since dairy inputs and services provisions are still at infant stage and the expansion of improved dairy cows is limited in the country, the increase in milk production came mainly from increased number of cows rather than increased productivity. In fact, the national estimate shows that average milk yield per cow per day for indigenous breed is low at about 1.37 liters. Given the ultimate limitation of resources such as land, productivity can be improved significantly through efficiency gains and the use of improved technology.

In the case of Ethiopia, the options for new technology introduction and resource expansion are few. This leads one to believe that measuring the extent of technical efficiency and sources of inefficiencies in production under existing technology and input very important for advancing discourses on the topic and also providing policy relevant suggestions. Therefore, it is essential to identify the level of efficiency & sources of inefficiency in order to design development policies to improve performance (Lovell, 1995). These calls for better understanding of the efficiency level of the country's dairy sector in general & the case of Sululta in particular, and identifying inefficiency factors to better inform research, development and policy decisions and also help to prioritize interventions to develop the dairy sector.

There exist several studies on efficiency analysis of Ethiopian agriculture (Alene et al. 2005; Haji 2006; Makombe et al. 2011 and Nisrane et al. 2011). However, there are only a few studies on milk production (Zewdie et al. 2015; Asres et al. 2013 and Nega 2006) and all of them were conducted their studies at national or regional levels. Due to several factors that cause heterogeneity and other problems in estimation, pooling of regional or national data together for such kinds of analyses creates bias in results and hence a case study of the subject on a relatively similar agro-ecology sounds better. This study, therefore, tried to contribute to the existing gap in knowledge on efficiency factors in dairy production in Ethiopia and the case in point is Sululta District as a case study.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of the study is to investigate the technical efficiency of Commercial dairy farms involved in milk production in Sululta district.

1.3.2. Specific Objectives

The specific objectives of the study are:-

1. To measure the level of technical efficiency of dairy farms involved in milk production in Sululta district.
2. To identify the principal factors that causes efficiency differentials among dairy farms in the study area.

1.4. Significance of the Study

The identification of the extent of the technical efficiency and factors associated with inefficiency are important for government policy intervention that aims at increasing production either through decreasing the level of inputs without decreasing the level of output or producing a given level of output by using the proper combination of inputs.

This study made an attempt to provide useful information for policy makers with regards to technical inefficiencies in milk production and help to identify those factors that are associated with inefficiency. Thus, it is hoped to contribute to formulation of policies and strategies to increase milk production. Informed policy and strategy formulation is an effective means of achieving national goals for poverty reduction.

In addition, the study would contribute in provision of useful information in the analysis of technical efficiency differentials in milk production and determine technical inefficiency factors that differentiate farms' milk productivity. Finally, the document may serve as a reference material for those who are interested in the area of efficiency analysis in dairy production.

1.5. Scope and Limitation of the Study

1.5.1. Scope of the Study

This study covered the 46 commercial dairy farms operating in Sululta district of Oromia Regional State of Ethiopia. The study treated and analyzed the data collected from 2015/16 production season to estimate their technical efficiency.

1.5.2. Limitation of the Study

This study has limitations that emanated primarily from shortage of budget, and facilities. In the first place, the study was conducted using a cross-sectional data of 46 commercial dairy farms to analyze the technical efficiency level and the principal determinants for the variation among dairy farms, which only reflects farms' circumstances in a given year. This may be affected by the specific climate of the year as agriculture in the country in general, and in the study area in particular, is dependent on weather. Moreover, the results of cross-sectional data do not show the change over time that is important for a follow up development strategy.

1.6. Organization of the Study

This thesis is organized into five chapters. The first chapter is an Introduction that comprises background of the study, statement of the problem, objectives of the study, significance of the study, scope & limitation of the study. Chapter two is literature review, where the analytical foundations of theoretical and empirical literature of efficiency measurements are well discussed in the chapter two. Following this, chapter three discusses about research methodology used in the study. Whereas, chapters four deals with results and discussions. Finally, the last chapter concludes and stressed the policy implications of the based on its findings.

CHAPTER TWO: LITERATURE REVIEW

In this chapter, concept of basic terms, review, problem of dairy sector in Ethiopia and importance of milk, theoretical perspectives on efficiency analysis, models for measuring efficiency, approach to measurement of technical efficiency and empirical studies on efficiencies analysis have been reviewed.

2.1. Theoretical Issues

2.1.1. Concepts of efficiency

Efficiency may be described as the relation between ends and means (Afriate, 1972). Farrell (1957) identified two components of production efficiency: technical efficiency and allocative efficiency.

Technical efficiency reflects the ability of a firm to attain optimum level of output from a given bundle of input. In other words, technical efficiency can be described as a situation wherein it is impossible, with current technical knowledge, to raise output from given inputs or, alternatively, to produce a given output by using less of one input without using more of another input (Tedla, 2002). Technical efficiency measures are calculated relative to the production function of the fully efficient farm or unit, which is represented by a frontier function.

Technical inefficiency on the other hand refers to failure to operate on the production frontier and is generally assumed to reflect inefficiencies caused by timing and method for application of production inputs (Lieweyn and Wiliams, 1996). It may also arise because of excessive input usage, which prevents cost minimization and profit maximization. In general, it arises when actual or observed output from a given input mix is less than the maximum possible and it can stem from a variety of sources, including a lack of knowledge of available techniques or inadequate management due to lack of motivation, skills and/or personnel (Scarborough and Kydd, 1992).

The concept of technical efficiency relates to whether a firm uses the best available technology in its production process (Chavas and Cox, 1988). 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 input (Byerlee, 1987).

Allocative efficiency measures success of firms in choosing optimal set of inputs (which Farrell calls “price” efficiency) and shows a firm’s ability to maximize profits by equating the marginal revenue product of the factors of production to their respective marginal cost(Abay, 1997).

Technical and allocative efficiency (price efficiency) in production, which together comprises economic efficiency are distinguished by Farell (1957) through the use of frontier production function or economic efficiency measures overall performance which is equal to TE times AE, i.e.EE = TE X AE

2.1.2. Technical efficiency and productivity

Most often, many scholars used productivity and efficiency interchangeably and consider both as the measure of performance of a given firm. However, according to Coelliet al. (1998) these two interrelated terms are not precisely the same. In simple term, productivity is the quantity of a given output of a firm (e.g. a farmer) per unit of input. Technical efficiency 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. All feasible points below the frontier are technically inefficient points.

2.2. Theoretical Perspectives on Efficiency Analysis

Technical efficiency is just one component of overall economic efficiency. However, in order to be economically efficient, a firm must first be technically efficient. Profit maximization requires a firm to produce the maximum output given the level of inputs employed, use the right mix of inputs in light of the relative price of each input and produce the right mix of outputs given the set of prices (Kumbhaker and Lovell, 2000). These concepts can be illustrated graphically using a simple example of a two input (x1, x2)-two output (y1, y2) production process (Figures 1 and 2). Efficiency can be considered in terms of the optimal combination of inputs to achieve a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output-orientation).

In production theory the main choices center on what to produce (i.e., which product or combination of products), how much to produce (the levels of output) and how to produce (the combination of inputs to use). The decision making unit is the firm which is defined as a “distinct agent specialized in the conversion of inputs into desired goods as outputs”. (Farrell, 1957). Technical efficiency may be defined as the ability of a firm to produce as much output as possible with a specified level of inputs, given the existing technology. Technical efficiency concerns the way in which physical quantities of input are converted into physical quantities of output. Farmers are said to be technically efficient if they achieve maximum feasible output from inputs.

According to the neoclassical definition of technical efficiency, a production process is technically efficient if and only if it yields the maximum possible output for a specified technology and input set. The concept of efficiency can be explained more easily using input or output oriented approaches. Farrell (1957) used an input-oriented approach to illustrate the measurement of efficiency. He used a simple example involving firms, which use two inputs, x1 and x2, to produce a single output y, under the assumption of constant returns to scale.

The constant returns to scale assumption allows to represent the technology using a unit iso-quant. Farrell discussed the extension of his method so as to accommodate more than two inputs. Knowledge of the unit iso-quant of the fully efficient firm, represented by TT' in figure 1, permits the measurement of technical efficiency. If a given firm uses quantities of inputs, defined by the point k, to produce a unit of output, the technical inefficiency of that firm could be represented by the distance yk, which is the amount by which all inputs could be proportionally reduced without a reduction in output. This is usually expressed in percentage by which all inputs could be reduced.

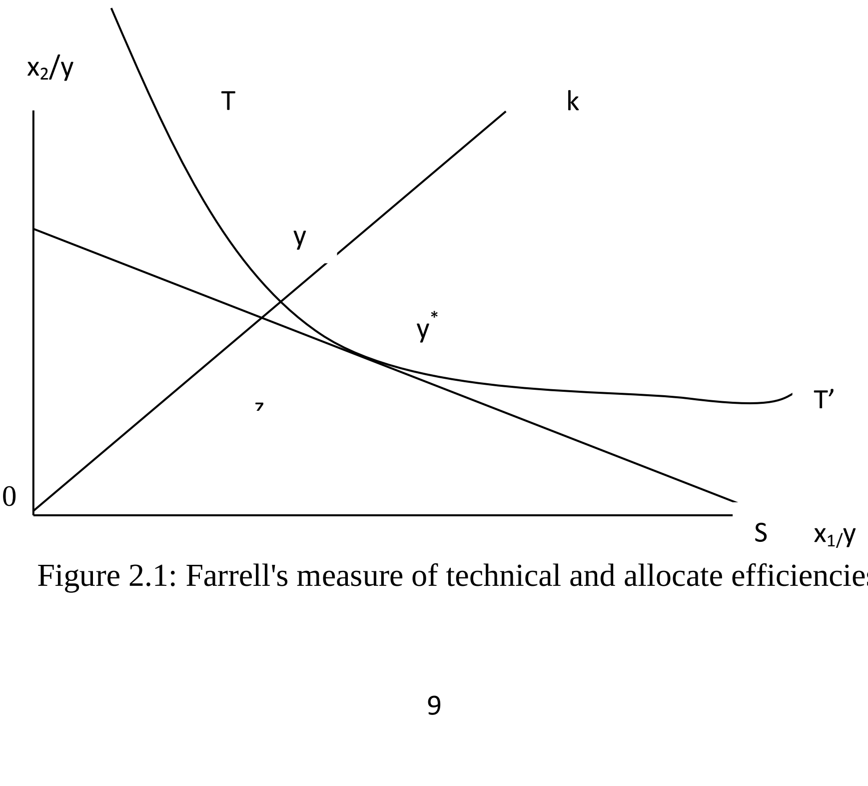

Figure 2.1: Farrell's measure of technical and allocate efficiencies

The Technical efficiency (TE) of a firm operating at k is measured by the ratio, TEk= oy/ok, which is equal to one minus yk/ok. TEk will take a value between zero and one, and hence provides an indicator of the degree of technical inefficiency of the firm. A value of one indicates the firm is fully technically efficient. For example, the point y is technically efficient because it lies on the efficient iso-quant.

Farrell has also demonstrated that the unit iso-quant provides a set of standards for measuring allocative efficiency. The iso-cost line SS' gives the minimum cost of producing one unit of output given relative input prices. The allocative efficiency (AE) of the firm operating at k is defined to be the ratio, AEk= oz/oy, since the distance zk represents the reduction in production costs that would occur if production were to occur at the allocatively (and technically) efficient point y*, instead of at the technically efficient, but allocatively inefficient, point y. The total economic efficiency (EE) is defined to be the ratio, EEk= oz/ok, where the distance zk can also be interpreted in terms of a cost reduction. Thus, the product of technical and allocative efficiency provides the overall economic efficiency measure.

Producers that achieve different output-input ratios may actually face different technologies, or the differences may arise from random disturbances, or some produce may be more successfully than others in exploiting the same technology. The failure of producers facing the same set of prices and production function to achieve the same level of efficiency arises from two sources: (1) the failure of some to avoid waste by producing as much output as input usage allows or by using as little input as output production allows i.e., the failure to operate on the technically efficient production frontier, and (2) the failure of some to combine inputs and outputs in optimal proportions in light of prevailing prices i.e., the failure to apply the level of inputs that maximize profits. The above two points, enable one to identify technical and allocative or price inefficiencies (Coelli et al., 1998).

The input oriented measure of efficiency addresses the question "by how much can input quantities be proportionally reduced without changing the output quantities produced?" (Coelli. et al.,1998). A farm can be on or above the unit iso-quant on the input per unit of output space and cannot be below or to the left to it. A departure from the unit iso-quant indicates technical inefficiency and the more a farm is far from the unit iso-quant the more it is inefficient.

Efficiency measure can also be expressed by using the output-oriented approach. “By how much can output be increased without increasing the amount of input use?” (Coelli et al., 1998). Such a question can be answered by using the output-oriented measure of efficiency. The failure of producers facing the same set of prices and production function to achieve the same level of efficiency arises from two sources: (1) the failure of some to avoid waste by producing as much output as input usage allows or by using as little input as output production allows i.e., the failure to operate on the technically efficient production frontier, and (2) the failure of some to combine inputs and outputs in optimal proportions in light of prevailing prices i.e., the failure to apply the level of inputs that maximize profits. The above two points, enable one to identify technical and allocative or price inefficiencies (Coelli et al., 1998).

2.3. Measurement Issues of Technical Efficiency

As indicated above, economic efficiency is composed of two components, namely, technical efficiency and allocative efficiency. Allocative efficiency refers to the extent to which a farmer combines inputs to achieve the greatest financial gain. As with allocative efficiency, if not more so, policy maker's conception of technical efficiency in peasant agriculture may influence the shape of development strategies.

Technical efficiency, which can have an output augmenting orientation or an input conserving orientation, is the measure of a firm's success in producing maximum output from a given set of inputs. A producer is said to be technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output.

Technical efficiency is concerned with the efficiency of the transformation of inputs to physical output. That is, for efficient production, farm output should lie on the envelope curve, or production function, which traces out the maximum quantities of output from varying quantities of inputs under a given technology. When technical efficiency is defined in terms of maximum output from a given bundle of measured inputs, it means that only those farmers who are technically efficient will operate on the production frontier. Farmers whose input- output performance falls below that of farms on the production function are classified being technically inefficient.

According to Farrell (1957) technical inefficiency arises when more than the least bundle of inputs is used to produce one unit of output. He puts several techniques for the measurement of efficiency of production. These techniques can be broadly categorized into two approaches: Parametric and non-parametric. The parametric production frontier production function approach and the non- parametric mathematical programming approach, commonly referred to as Data Envelopment Analysis (DEA) are the two most popular techniques used in efficiency analysis.

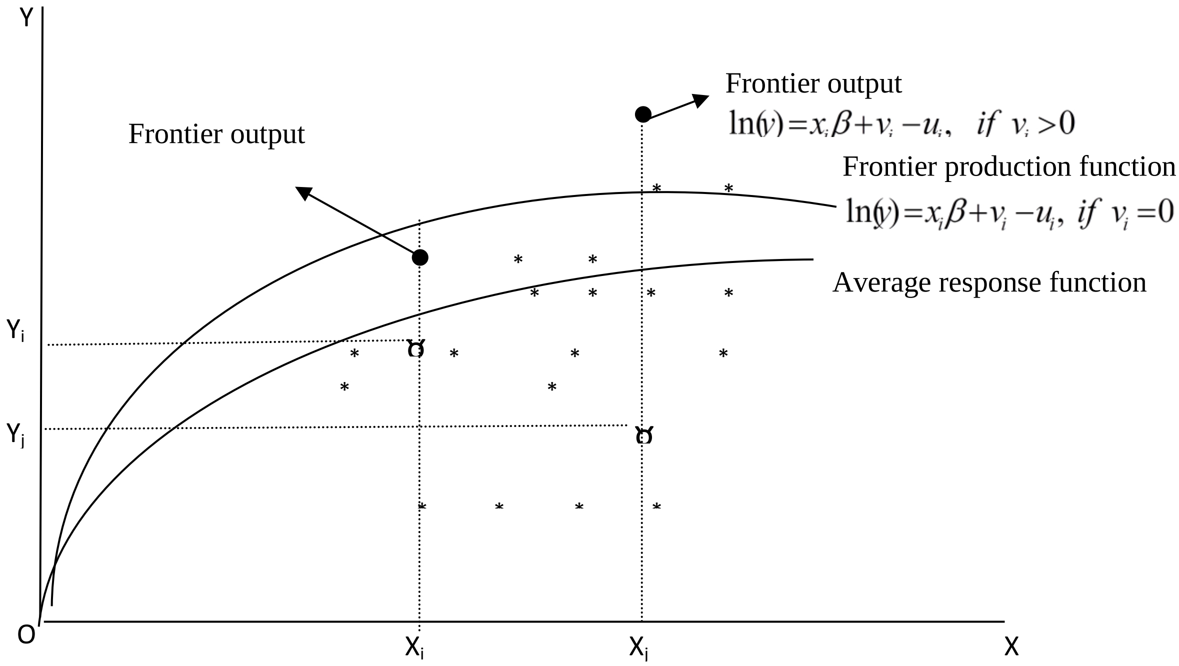

Figure 2.2: The Stochastic Frontier Production Function
Source: Adopted from Coelli et al. (1998)

Recent advances in the theory and practice of estimating stochastic ‘frontier functions” have brought empirical estimates of production functions much closer to their theoretical definition of envelop curves or frontiers. Among many authors, Coelliet al (1995) present the most recent review of various techniques used in efficiency measurement, including their limitations, strengths and applications in agricultural production.

The main strengths of the stochastic frontier approach are that it deals with stochastic noise and permits statistical tests of hypothesis pertaining to production structure and the degree of inefficiency. It is the only technique that distinguishes between random factors and inefficiency. However, the estimation of efficiency using stochastic method requires a prior specification of functional form.

Moreover, the estimation of ui(random term) needs distributional assumptions (half normal, gamma, truncated, etc.) (Coelliet al, 1998). In stochastic frontier, method technical efficiency is measured by estimating a production function. Different production functions such as Cobb-Douglas, Trans log, Transcendental, and Quadratic etc. can be used to estimate the frontier. The Tran slog and Cobb-Douglas specifications are commonly used functional forms to estimate the frontier; but both have their merits and demerits.

Stochastic frontier production functions have been applied in a large number of empirical studies to account for the existence of technical inefficiencies of production. In most cross-sectional studies, the technical inefficiency effects have been assumed to be independently and identically distributed, generally as half-normal or exponential random variables. However, in some empirical papers, the parameters of stochastic frontier production functions have been estimated and then the predicted technical inefficiency effects have been regressed on various farmer specific variables believed to be significant in explaining the level of technical inefficiency of the farmers involved.

This two-stage approach involves contradictory assumptions in that the technical inefficiency effects in the stochastic frontier are assumed to be independently and identically distributed to obtain prediction for their unknown values. However, expressing the predicted technical inefficiency effects in terms of a regression model involving other explanatory variables is not consistent with the assumptions of identically distributed technical inefficiency effects in the stochastic frontier. Coelli and Battesse (1995) propose a model in which the technical inefficiency effects in a stochastic production frontier are a function of other explanatory variables.

2.4. Conceptual Framework

The conceptual framework for this study is based on the institutional analysis and development (IAD) approach of the new institutional economics (NIE). In the IAD approach by Dorward and Omamo (2005) it is assumed that an exogenous set of variables influences situations of the agents and the behavior of the agents in those situations. This leads to outcomes which provide feedback to modify the exogenous variables, the agents and their situations.

The framework is operationalized as shown in Figure below, which represents how various factors inter-relate to influence Sesame productivity and hence the benefit of sesame producers. The policy environment is characterized by the existing political and economic trends in the country which have an influence on the farming system and indirectly determine the sesame output. However, within the farming system various sets of factors interrelate to determine sesame productivity.

Production factors such as seed, labor, cows and feed are used as inputs into the production process. The availability and distribution of these inputs may be influenced by the policy framework in place, which in-turn determines the extent of sesame productivity. It is expected that the more inputs used by the farmer, the higher the milk yields per liters.

Milk productivity is also affected by the farm production efficiency. This is supported by the notion that for a production process to be effective, the manner in which available farm resources are utilized is crucial. But the farm's production efficiency is also influenced by institutional and socio-economic characteristics of the farmer. Institutional factors are expected to influence production efficiency as follows: The nearness to the market, group membership, and credit-access and extension service are hypothesized to have a positive influence on production efficiency. Then access to extension service provides farmers with information on better methods of farming and improved technologies that improve their productivity.

With respect to socio-economic characteristics of the farmer, it is hypothesized that age of the farmer positively affects production efficiency. An off-farm activity is expected to have a positive effect on production efficiency; since farmers with such incomes have a regular source of income that they can use to acquire farm inputs. Schooling is expected to have positive results since; on the one hand, educated farmers committed in farming may be able to take up improved technologies faster because they understand the benefits associated with the technology, hence increasing their efficiency.

In addition, farmer's experience is expected to positively influence production efficiency because experienced farmers are better producers, who have learned from their past mistakes; hence they make rational decisions compared to less experienced farmers.

A farm that is technically, efficient is therefore expected to realize higher milk output per liters compared to one that is less efficient in production. But on the other hand, such a firm is hypothesized to incur less production costs leading to higher returns from the enterprise. This therefore has positive spillover effects on the welfare of the milk producing farms. Improved welfare of the households then provides a feedback effect in form of increased access to production inputs and relevant lessons to policy makers.

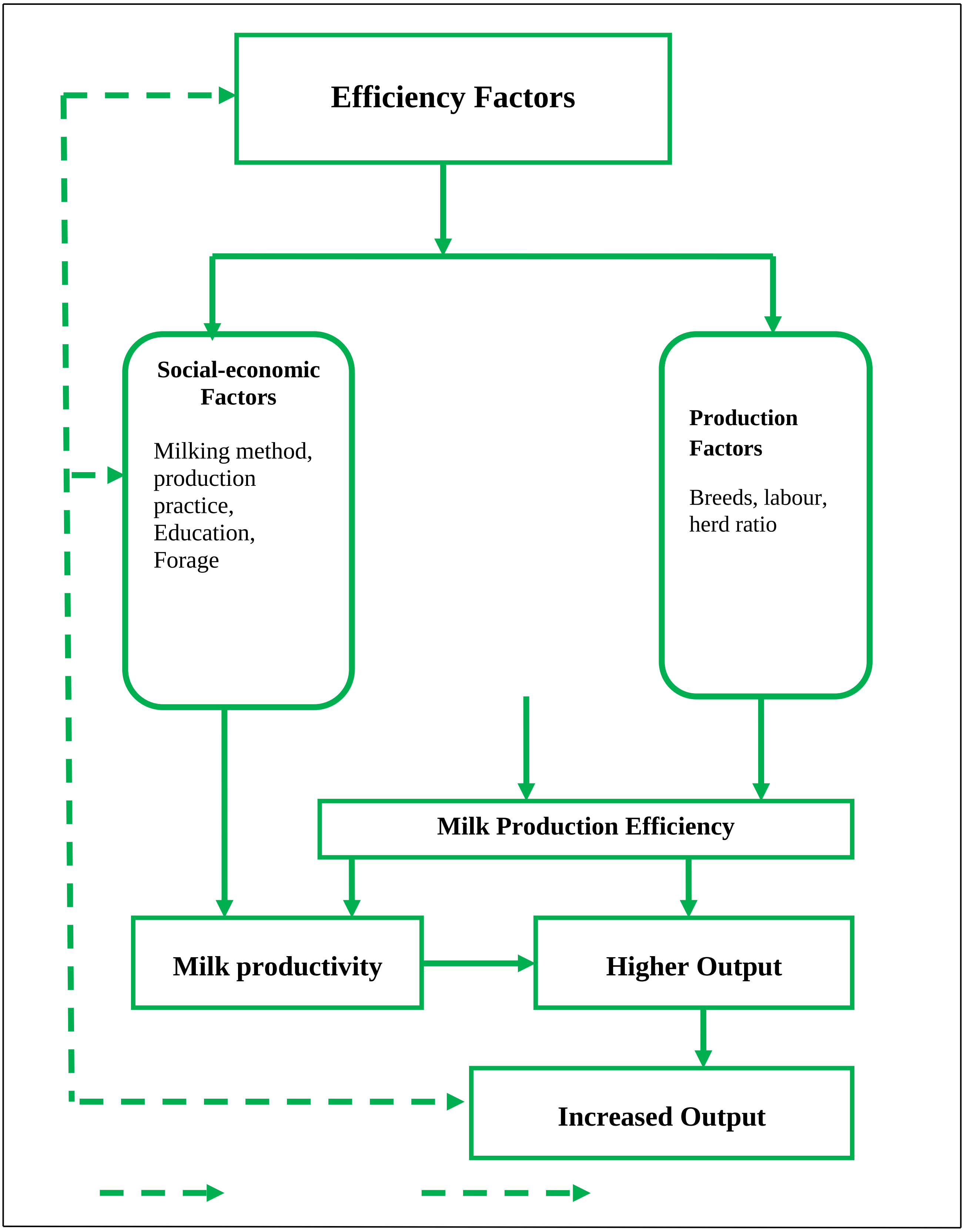

Figure 2.3: The conceptual framework of factors influencing technical efficiency ***(Adapted from New Institutional Economics theory)***

2.5. Importance of Milk to Human Being

Milk is considered as a nearly complete food since it is a good source of protein, fat and major minerals. Milk and milk products are main constituents of the daily diet, especially for vulnerable groups such as infants, school age children and old age (Enbet al., 2009; Li-Qianget al., 2009). It is an ideal source of macronutrients such as calcium (Ca), Potassium (K), and phosphorous (P) and micronutrients such as copper (Cu), iron (Fe), Selenium (Se), and Zinc (Zn). These are known to be essential for normal growth (Li-Qianget al., 2009). These metalsare co-factors in many enzymes and play an important role in many physiological functions of humans and animals.

Lack of these metals cause disturbances and pathological conditions (Enbet al., 2009). This fact is particularly true in the case of early childhood, because milk is the only source of nutrients during the first months of a baby's life and the diet of growing children contains a high proportion of milk and milk products. An appropriate intake of milk is also recommended for adults as a source of calcium to retain bone mass so that fractures and osteoporosis can be prevented.

Deficiencies of most micronutrients are known to have devastating health consequences. They increase the overall risk of mortality and are associated with a variety of adverse health effects, including poor intellectual development and cognition, decreased immunity, and impaired work capacity. The adverse effects of micronutrient deficiencies are most severe for children, pregnant women, and the fetus, and approximately 30% of the world's population is unable to use their full mental and physical potential as a result of micronutrient malnutrition (Federal Ministry of Health, 2004).

2.6. Review of Ethiopian Dairy Sector

Milk production in Ethiopia increased significantly during 1960s. Between 1961 and 1974, milk production from all species increased by 16.6% from 637 thousand metric tons to 743 thousand metric tons, with an average annual growth rate of 1.63%. This growth was largely due to the expansion of large scale production (Staalet al., 1996).

Following the 1974 revolution, the government shifted attention from urban producer to rural producers. Despite the shift in policy, substantial resources were devoted to establishing large-scale state farms to provide milk for urban consumers. This phase was characterized by intensive effort by the government and donors towards developing the dairy sector through producers' cooperatives. The entire program was intended to bring about improvement in milk production and income through introduction of improved feeding, breeding and health improvement programs while less attention was given to marketing and processing (Mohamedet al., 2003).

During the first half of the 20th century, dairy in Ethiopia was mostly traditional comprising entirely indigenous breeds. Modern dairying started in the early 1950s when Ethiopia received the first batch of exotic dairy cattle from United Nation Relief and Rehabilitation Administration (URRA). With the introduction of these cattle in the country, commercial liquid milk production started on large-scale farms in Addis Ababa and Asmera (Ketema and Tsehay, 2005).

Government intervened through the introduction of high-yielding dairy cattle on the highlands in and around major urban areas. The government also established modern milk processing and marketing facilities to complement these input oriented production efforts. Most interventions during this period focused on urban-based production and marketing including the introduction of dairy, concentrate feed, modern dairy infrastructure and high management level.

In general, Ethiopia has great potential for dairy development. Favorable conditions for dairying are the country’s large and diverse cattle population, generally adequate rainfall patterns which offer potential for production of high quality feedstuff, the existence of a large labor pool and opportunities for export (SNV, 2008; Antenehet al., 2010). Particularly the mixed crop–livestock system in the highlands, although resource-limited, offers the best opportunity for dairy development and can support crossbred and pure dairy cattle breeds.

A prerequisite is the development of well-designed breeding strategies (Effaet al., 2003; Ahmedet al., 2004; MoARD, 2007). Current impediments of livestock development are poorly developed social sector and economic infrastructure as well as environmentally destructive trends (MoARD, 2007). During the last decade cropping area has increased at the expense of grazing land, especially in Ethiopia’s highlands. Decreasing grazing land combined with a rapidly growing livestock population (CSA, 2011) is likely to lead to massive overstocking and overgrazing of available pastures and increased land degradation due to soil erosion (Blata, 2010;

Tschoppet al., 2010). This stretches pasture capacity beyond its limits; consequently decreasing pasture quality results in low livestock production performance (SNV, 2008).

2.6.1. Actors in The Ethiopian Dairy sector

2.6.1.1. Smallholder Dairy Producers

Smallholder dairy producers dominate the dairy industry at the production and are the users of the extension services provided by various development partners. Different players are linked and interact with smallholder dairy producers at various levels based on the type of ongoing joint venture activities. The actors are: extension agents, various non-governmental and international development partners mainly Food and Agricultural Organization (FAO), Netherlands Development Organization (SNV), Land O'Lakes, Self Help, Hunde (in the central highlands), cooperatives and research and higher education institutions (Yilma et al., 2011).

Smallholder producers, however, lack the required technological, organizational as well as institutional capacities. Lemma et al., (2008) reported them to be less organized and distant from market outlets, lack economies of scale and institutions for risk management and face higher transaction costs. Urban and peri-urban smallholder producers are the main suppliers of raw milk to milk processors of different scales. One of the major commercial processors (Sebeta Agro Industry) has its own dairy farm but depends on outside sources for 99 percent of its raw milk intake (Haile, 2009).

2.6.1.2. Dairy Cooperatives and Unions

Cooperatives play a significant role in ensuring sustainable supply of raw milk to the dairy industry by coordinating the flow of milk from their members and assisting them by supplying the required dairy farm inputs. Emana (2009) reported that there are 180 cooperatives engaged in milk production and marketing operating in different parts of the country. However, this number makes only 0.74 percent of the total number of agricultural and non-agricultural cooperatives (24 167) and 2 percent of agri-based cooperatives (8 985) in the country. According to the same author, there are a total of four (two each in Amhara and Oromia Regions) milk production and marketing cooperative unions that are formed by cooperatives for better marketing capability and bargaining power. Ada'a Dairy Cooperative is the most successful, while Selale and Asella Dairy Cooperative Unions are currently performing fairly well.

2.6.1.3. The Ministry of Agriculture

Dairy development in the country is undertaken by the Government represented by the Ministry of Agriculture (MoA). MoA is the government's main arm for agricultural policy formulation and technical supervision including designing strategies, preparation of programs, capacity-building, providing trainings and coordinating national agricultural development projects. The principal function of MoA is to provide technical backstopping and budgets to regional agricultural development bureaus and direct farmers support through extension services. In the livestock sector, MoA retains control of federal responsibilities in animal disease-monitoring, vaccination campaigns and artificial insemination (AI) programs (GRM International BV, 2007).

MoA's main objective is to improve the livelihood and income of producers by increasing livestock productivity and profitability. This is done through the provision of extension services to smallholder dairy producers on different improved livestock technologies, building of technical capacity of producers, promotion of collective action (formation of cooperatives and unions), and facilitation of linkages with other national, regional and international organizations engaged in dairy research and development for further innovations. Dairy cooperatives and unions provide a regular market outlet to member and non-member smallholder producers that produce small amounts of milk daily.

2.6.1.4. Local and International Development Partners

Different national and international development partners have been involved in the development of the country's dairy sector by providing material and technical support to smallholder producers, dairy cooperatives and unions and the private sector. The major development partners currently involved in dairy development at different levels and in different dairy potential areas of the country include: SNV, Land O'Lakes, FAO, Heifers International Organization and Non-Governmental

Organizations (NGOs) such as Self Help and Hunde that operate in the central highlands.

Land O'Lakes provides technical assistance to dairy farmers, producer groups and cooperatives, input suppliers and processors. The objective of this assistance is to have a competitive Ethiopian dairy industry built upon private investment that creates employment and generates income for smallholder families and provides quality products to local consumers. The key components of the technical assistance include: milk shed development, stimulation of business development, strengthening of market linkages among stakeholders and advancement of dairy industry organization.

SNV through its 'Support to Business Organizations and their Access to Markets (BOAM) program, supports the development of value chains by establishing market linkages, bringing value chain actors together, developing agro-processing activities and linking the private sector to public sector initiatives. It can also where possible work with the Dutch business community, from local producer organizations and processing companies to multinational partners. The overall aim is to increase the access of Ethiopian companies to markets. The three strategic intervention areas of the dairy industry include: milk collection centers and linkage to farmers milk packaging and quality management. Reports of research results on various aspects of the dairy sector conducted by SNV are available at http://www.sustainable-ethiopia.com/.

FAO is involved in dairy development activities with the major objective of raising the subsistent type of smallholder dairy production to commercial level through its 'Crop Diversification and Marketing Development' Project. The principal activities include: distribution of crossbreed heifers to increase milk production (thereby increasing the amount of milk delivered to milk collection, processing and marketing cooperative centres), establishment of new cooperatives and upgrading the existing ones, improvement of the marketing channel through improving quality of products, the marketing system and identifying linkages between producers and consumers. FAO is also engaged in need assessment studies for future improvement interventions in areas such as actor linkages in dairy innovation system, climate change and livestock production and trade.

2.6.1.5. The Private Sector

The private sector constitutes an important part of the dairy sector. It is engaged in providing farm inputs (feed and veterinary drugs), animal health care and milk processing and storage equipment and serves as an important market outlet for milk and milk products. Commercial processors are those adopting modern technology with the majority of their output being pasteurized milk in packs of 500 ml. Currently, there are over 22 medium- and large-scale dairy processing companies in Ethiopia with nine of them operating in Addis Ababa and the rest in other major regional cities

2.6.1.6. Research Institutions

Dairy development research endeavors have been oriented towards genetics, husbandry, feed-resource management, animal nutrition, physiology, animal health, dairy processing technology, social economics and technology transfer. Research work has been undertaken on-station and whenever necessary followed by on-farm verifications. The Holetta Agricultural Research Centre (HARC) of the Ethiopian Institute of Agricultural Research (EIAR) serves as a center of excellence for dairy research. The center coordinates all dairy improvement research activities in the federal system as well as in different regional states including joint venture research activities with agricultural universities and colleges. Both federal and regional research institutions adopt and generate appropriate technologies for dairy development and are also involved in capacity building by organizing and providing trainings. They verify and demonstrate promising technologies on farms with the participation of smallholder farmers.

2.6.1.7. Higher Learning Institutions

Higher learning institutions are involved in providing long term trainings on a regular basis to high level agricultural professionals and short term trainings on request. Universities that provide long term trainings on dairy related fields include: Haramaya University, Hawassa University, Bahir Dar University, Jimma University, the Veterinary Faculty of Addis Ababa University, and the Asella Model Agricultural Enterprise (AMAE) of Adama University.

There are also 25 Agricultural Technical Educational and Vocational Training (ATEVT) Schools operating in different parts of the country that accept students who have completed tenth grade and provide them a three-year diploma program in one of five disciplines: Animal Science, Animal Heath, Agricultural Cooperatives Development, Natural Resources, and Plant Science. All ATEVT schools offer Animal Science, Natural Resources and Plant Science, while a few others offer Animal Health and Agricultural Cooperatives. The ATEVT curriculum was first introduced in September 2000 by the Ministry of Agriculture and Rural Development, (MOARD) in 28 ATEVTs located across the country. In 2001, the number was reduced to 25. The 25 ATEVTs graduated the first Development Agents (DAs) in 2004. By 2008, the colleges had produced nearly 60 000 DAs (12% of them women). ATEVTs seek to produce mid-level skilled and competent agricultural DAs who will then teach farmers at Farmers Training Centres (FTCs). There are two categories of ATEVT colleges: federal and regional colleges. There are seven federal colleges (four in the large regions and three in the emerging regions) that report to and are managed by the MoA. The rest (regional colleges) are managed by the regional Bureaus of Agriculture (BoA) or the Ministry of Education through the Technical, Educational and Vocational Training (TEVT) Commission or Agency (Davis et al., 2010).

2.6.1.8. Other Important Players

There are also a number of other important players that contribute to the development of the dairy sector. The National Artificial Insemination Centre (NAIC) imports semen of pure exotic breeds, produces semen from selected crossbreed bulls from its Holetta Bull Dam Farm and liquid nitrogen. NAIC distributes semen to nine sub centres (Liquid Nitrogen Plants) located in five regions, namely: Oromia (Nekemt and Asella), SNNP (Wolayta and Wolkite), Amhara (Bahir Dar and Dessie), Tigray (two sub centers in Mekelle) and Harar. NAIC also provides training on AI service provision to AI technicians as trainees and trainers. The major functions of the sub centres include: supplying AI inputs (semen, liquid nitrogen and AI equipments), providing and coordinating AI services in the respective regions. Established in 2008 at Debre Zeit, the ‘Ethiopian Meat and Dairy Technology Institute’ (EMDTI) provides tailor-made trainings on different aspects of dairy development. Banks and microfinance institutions are also playing an important role in the dairy development of the country. Colleges, universities, hospitals, cafes and restaurants of big enterprises can be categorized as institutional buyers of milk with most of them sourcing from collectors (Haile, 2009).

2.6.2. Problems of Dairy Sector in Ethiopia

There are considerable inefficiency challenges that have greatly retarded the productivity of the livestock sector in Ethiopia. Livestock production lacked the policy level attention it deserves (Gelan*et al.,* 2012). For example, the Ethiopian public agricultural research staff allocated to crop research accounts for 56.8% whereas only 14.2% researchers focused on livestock (IFPRI, 2011). Slow innovation and technology transfer such as shortage of genetic material, insufficient supply of forage crop seeds and feed concentrates are observed. Complementary services such as extension, credit, breeding, veterinary service, and input-output marketing are poor (MoARD, 2010). All these constraints are often considered to evaluate where further efficiency gains are possible.

A number of studies have examined the potential of the Ethiopian dairy sector to meet the expected growth in demand as well as to improve the incomes of the farmers (Mohamed et al., 2003). Many of those studies, however, focus on technological constraints of the sector including poor genotype of local breeds, 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.

According to Zelalem et al. (2011) the following constraints account for the poor development of the dairy sector in Ethiopia; such as, lack of market outlets for milk and milk products, inefficient and untimely artificial insemination (AI) services and poor semen quality, lack of crossbreed heifers, shortage of feeds especially agro-industrial by-products, shortage of water and inefficient and inadequate milk processing technologies.

2.7. Empirical Studies on Efficiency

2.7.1. Empirical Studies outside Ethiopia

Monika et al. (2013) analyzed the technical efficiency (TE) of the milk production on 83 cattle herds (database of APRC Nitra- Lužianky, Slovakia Republic) in the period 2006-2010 and to synthesize the impact of main inputs (costs) on the TE value. A nonparametric approach Data Envelopment Analysis with the input-oriented variable return to scale model was used to evaluate the TE value. Average value of TE in the analyzed period was 0.96, i.e. evaluated herds reached 96% of technical efficiency in milk production on average. For these, reduction of inputs by 4% is recommended to reach the efficiency at the given level of milk yield. Value of individual inputs: total feed cost, material cost, labour cost, repair and service, depreciation, other direct costs and overhead costs, should be reduced by 3.7, 10.0, 3.3, 15.8, 2.1, 2.9 and 8.5% respectively, while maintaining the same level of output. It is possible to state that the analyzed farms are inefficient in utilization of inputs for the given level of output. The TE value was statistically significantly and influenced by the feed costs only. The negative influence of this factor indicates inefficient utilization of feeds (balance of feeding ration, losses of storage, reciprocal substitution of feeds) or inefficient utilization of its production potential in relation to the given output level.

Bardhan and Sharma (2013) used stochastic frontier production function analysis to estimate technical efficiency of milk production in Kumaon division of Uttarakhand state of India. The objective of the study is estimating technical efficiency of milk production across different herd-size category households and factors influencing it. To determine the technical efficiency of the different herd-size categories of households across groups, the mean technical efficiency indices of milk production for different sample farms were obtained.

The mean efficiency of households in plains and hills were almost same (90.73 and 89.27, respectively). Small farmers were the most efficient in the plains (mean efficiency of 94.57), followed by large (mean efficiency of 92.62) and medium famers (mean efficiency of 84.40). In the hills also, small farmers were more efficient (mean efficiency of 90.31) than their medium counterparts (mean efficiency of 85.49). Based on the technical efficiency of the most efficient farm in each herd-size category, the average potential to increase milk production was determined.

The potential for technical efficiency improvement of milk production in terms of reducing milk production costs was higher for medium and large farms (14.62% and 6.51%, respectively) than that for small farms (5.34%) in the plains. Overall for all categories of households - if the average farmer was to achieve the efficiency level of its most efficient counterpart, then he would realize a 9.18 per cent cost saving. Mean potential to increase efficiency for small and medium category farmers in the hills were 8.62 per cent and 14.01 per cent. Mean potential to increase efficiency for overall category was 10.01 per cent. 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 per cent cost saving.

Duron and Huang (2013) employed the stochastic production frontier (SPF) model to provide the technical efficiency (TE) score and the determinants of TE of the dual-purpose cattle system (DPCS) in rainy and dry seasons in Morazán, El Salvador. For this study, the survey was conducted in a rural village, San Juan de la Cruz, where the highest cattle population is found. All the DPCS farmers in this village were interviewed twice, including during the rainy season of 2009 and the dry season in 2010. In the rainy season the main variable with positive effect on production was total cows and feed value in the dry season. Results from the SPF gave TE score of 65 % for rainy season and 84 % for dry season, on average. Thus, the stochastic model showed that the efficiency of this system could be improved by 35 % and 16 %, respectively, if public policies and managerial decisions create and respond to a secure environment in rural areas.

Burki and Khan (2011), in their report, provided empirical evidence on the impact of technical inefficiency of smallholder dairy producers when they formally participate in a milksupply chain. Here the stochastic production frontier and technical inefficiency effects model are estimated based on the data gathered from 800 smallholder dairy farms in Pakistan. The results suggest that the technical inefficiency of the participating farms is significantly reduced. A strong impact of the supply chain is also detected in reducing technical inefficiency of farms that are located in remote areas and on those that have larger herd-size. Experienced farmers up to the age of 36 years have the advantage of reducing technical inefficiency. The remaining differences in relative inefficiency of dairy farms are accounted for by severe long-term depressive disorders.

Demircanet 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, technical efficiency ranging from 28.6 to 100.0%, with the average being 64.2%. They reported 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. The study also finds no statistically significant relationship between contact with extension and the degree of farm production efficiency. In contrast to expectation, negative and statistically significant relationship was found between forage feed land size and production efficiency.

Sajjad and Khan (2010) used stochastic frontier production and cost function models to examine the economic efficiency of milk production in Peshawar district during 2009. Return to scale (RTS) for the production function revealed that the farmers operated in the irrational zone of the production surface having RTS of 1.074. The result of the analysis indicates that presence of technical inefficiency and allocative inefficiency had effects in milk production as depicted by the significant estimated gamma coefficient of each model. The estimated gamma parameter () for production function was 0.85 1, indicating that about 85% of the variation in the output of milk among the farmers was due to differences in their technical efficiencies while the estimated gamma parameter () of model for the cost function was 0.781 indicating that about 78% of the variation in the total cost of production among the farmers was due to the presence of allocative inefficiency. The result also showed that rising age would lead to a decline in the efficiency means, and recommended that Government policy should focus on ways to attract and encourage young people who are agile and aggressive in dairy business.

Kinambuga Dennis (2010) employed Data Envelopment Analysis in his M.Sc. thesis submitted to Egerton University in Kenya to come up with profit efficiency rankings among the dairy farmers, and the Frontier Model was used to establish factors that constrain profit efficiency. The data was processed using STATA and DEA frontier packages. The mean efficiency according to the results was 86%. The factors that were significant in explaining profitability efficiency according to the frontier results were: feeding systems (-0.38), breed type (-0.11), gender (0.37), debt amount (-0.0002) and debt asset ratio (21.43). Issues of trust were also found to have effect on profitability, and they included trust on local buyer price (0.52), trust on institutional buyer unit of measure (-0.1.77), and trust on middlemen unit of measurement (-0.05). The positive sign signifies that the factor increases profit inefficiency while the negative sign indicates that the factor reduces profit inefficiency.

Kumer and Jain (2008) used stochastic frontier production method to evaluate farm households in terms of their efficiency in milk production. The technical efficiency of crossbred cow farms varied from 72.30 to 97.90 percent with an average of 82.10 percent. The study indicated that there existed a scope to increase milk production of an average farm by 16.32 percent crossbred cow and 14.04 percent for buffaloes without incurring any extra expenditure on the farms.

2.7.2. Empirical Studies of Efficiency Analysis in Ethiopia.

Lemma et al. (2013) used stochastic frontier production function of the Cobb-Douglas model to estimate the technical efficiency of milk production. The study was conducted to indicate the determinants of technical efficiency of the dairy farmers in Ada'a district of Oromia state, Ethiopia. The study revealed that mass media exposure of the dairy farmers, training on dairy farming, dry fodder and concentrate feeds were the significant determinants of technical efficiency differentials of milk production in the study area. Organizational participation of the farmers, education level, labor and experience of the farmers in dairy farming had also positive effect on the technical efficiency of milk production. The results obtained with this study suggest that there is a need to strengthening the existing extension services to address the determinants of technical efficiency of the dairy farmers to bring about significant increase in milk production and a balance in demand and supply of milk production in the study area.

Amlakuet al. (2013) modeled Cobb-Douglas stochastic frontier production function by considering the impact of local level agricultural innovation systems framework on 2011 milk production in four districts of Amhara region. The study provides estimates of smallholder household's production efficiency and its determinants, and separately analyses the technical efficiency of dairy technology adopting and non-adopting farmers using data from Ethiopia. Results show that the mean level of technical efficiency among the sampled farmers was about 26%. 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 (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. The significant gamma () statistic, of 0.9985 in the analysis indicates that about 99.85% variation in the output of milk production would be attributed to technical inefficiency effects (those under farmer's control) while only 0.0015% would be due to random effects, i.e., beyond the farmers control and hence calling for a focus on efficiency enhancing investments. Education, farm size, extension visit and off-farm income opportunity were found to be efficiency enhancing. The study recommends that different components of an agricultural innovation system have to interact to improve the innovation capacity of different actors and thereby improve the estimated technical inefficiencies.

Hassenet al. (2012) analyzed the efficiency of crop-livestock production and assessing their potential for improvement in North-East Ethiopian highlands. Cross-sectional data were used to analyze the economic efficiency of mixed crop and livestock production system and identify its determinant factors. The parametric stochastic frontier approach was employed tomeasure economic efficiency. Their result indicated that most farmers in the study area were not efficient with the mean technical efficiency, allocative efficiency and economic efficiency of the households calculated from parametric approach of stochastic frontier analysis being 62%, 51% and 29%, respectively. Results also showed that improved agricultural technology adoption significantly improved production efficiency of households. They suggested that the technology adoption and production efficiency of the crop-livestock farmers should be improved by raising their education, farm household asset formation and by providing extension and credit services.

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. The paper is based on a research study among 168 dairy farms (85 cross breed and 83 local breed) in a town (Mekelle) of northern Ethiopia. A two stage stratified random sampling procedure was used to select the specific farm households. 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. The Cost Benefit results indicated that cross breed farms were profitable (1.0:3.02) than local breed farms (1.0:2.18). Both medium and small categories of cross breed farms were profitable (1.0:3.45 and 1.0:2.74). Among local breed, medium size farms are profitable (1.0:2.19). The ratio of break-even milk output for cross breed and local breed cows farms needed 13% and 18% additional milk production to cover fixed cost, respectively. To conclude, dairy cow's owners should be advised to use the optimum levels inputs and replace their indigenous cow with cross breed cow. Moreover, the herds should be medium size and feeding mainly depends on concentrate.

Nega and Simeon (2006) analyzed the inefficiency of smallholder dairy producers in the central Ethiopian highlands with the stochastic production frontier technique. The results confirm the existence of systematic inefficiency in milk production. The average efficiency level of the farmers is only 79% implying that milk output can be increased on average by21% with the existing technology by training of dairy farmers better production techniques. The gamma statistic, which is a measure of the overall, is highly significant indicating the presence of a high systematic inefficiency which explains about 90% of the variation in milk output. Accordingly, the elasticity of milk output respect to forage is 0.43 indicating that for a kg increase in forage feed milk output increases by 0.43 liters. The number of local breed cows and family and hired labor hours were not significant. Moreover, the sign of the family and hired labor coefficients are not expected, but since the variables are not significant it may not be important. The efficiency in production of individual farmers can be improved by training farmers in proper feeding, calving, milking, cleaning of cows, storing milk, marketing as well as other management skills.

The literature review above prevails that at the existing level of technology and factor endowment, there is a potential to boost agricultural output by improving the internal efficiency of the farms. Moreover, to the best of my knowledge, none of the studies have conducted on technical efficiency of milk production particularly in the study area. Besides, the review of literature indicates that the stochastic frontier approach is adopted to study technical efficiency of different sectors, indicating that it’s wider application and also appropriateness for agricultural sector.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Description of the Study Area

Sululta district is one of the six districts of Oromia Special Zone Surrounding Finfinne of Oromia National Regional State. The districts' capital town, Chancho, is 40 km away from Addis Ababa towards the North-west. According to CSA (2012), population of district was estimated at about 149,494 (male 74,753 and female 74,741). Concerning the land use pattern, out of the total area of the district which is 109,269 ha, about 26,662 ha (24.4%) is cultivated land, and 15,145 ha (13.9%) is covered by forest, bush and shrub land, 38,720 ha (35.4%) is grass lands, and 28,742 (26.3%) are other land use types (SDAO, 2012).

The district is bordered with different districts of North Shewa zone; Welmera in the West, Wuchale in the North, Jida in the East, Addis Ababa city administration in the South. The altitude of the district ranges from 2,851 to 3,700 meters above sea level. The highest annual rainfall is 1,447 mm with mean of 1,140 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 December to 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 source of livelihood in the district.

The main farming of the study area is livestock rearing followed by crop production, mostly cereal crops such as barley, wheat, teff, and pulse crops. The livestock feed source is hay, crop residue and grazing land. The total cattle population in the district is estimated at 224,600 (15% are cross-breed) (SDAO, 2012). The district has 23 kebele administrations, 3 sub-towns (Chancho, Dubar 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 (SDCU, 2012).

3.2. Sampling and Data Collection

The study was undertaken following the formal survey procedure where data collection for quantitative information is gathered using structured questionnaire and selecting a representative sample from a given population. The reason behind sampling is that in a real world it is difficult to implement census where time, human and financial constraints are the major bottlenecks. Taking these practical constraints in to account the study was conducted in one purposively selected Sululta district among the six districts of Oromia Special Zone Surrounding Finfinne of Oromia National Regional State.

Due to the importance of milk and production potential of the area to the products Sululta district was purposively selected. Two-stage random sampling technique was employed to select sample dairy farms for this study. In the first stage, six kebeles were selected from this district by using stratify random sampling procedure based on the number of dairy cows they owned. In the second stage, a total of 46 sample dairy farms were randomly selected from the sampling frame of commercial dairy farms of six kebeles by using simple random sampling technique. Taking the number of dairy farms in each kebele into account, the sample size of dairy farms was allocated for six kebeles based on probability proportional to size. The total sample size for this study is determined using the formula developed by Yamane (1967). According to this, sample size is calculated as:

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

Where,

n: sample size for the researcher use.

N: total number of commercial dairy farms in six kebeles = 72

e: designates maximum variability or margin of error = 0.05-0.1%

e = 0.09 was taken as margin error. It was taken because, as “e” gets approach 0.05 the sample size get larger and larger and as a result it becomes difficult to manage it.

3.3. Sources and Method of Data Collection

The formal method of data collection was undertaken by employing structured questionnaires designed in English and orally administered to dairy farm head & owners in Amharic language as needed.

The process of primary data collection was conducted through multiple visits, which enabled us gather timely and reliable information on the overall operations of dairy farms in the study area.

The secondary data that pertain to published and unpublished information about the study area were also collected from different sources.

3.4. Methods of Data Analysis

3.4.1 Descriptive analysis

This method of data analysis refers to the use of ratios, percentages, mean and standard deviations in the process of examining and describing socio-economic characteristics of dairy farms in the study area.

3.4.2 Econometric analysis

There is always a trade-off as to whether to choose the stochastic frontier approach which is prone to misspecification bias or the DEA which suffers from measurement errors (Erkoc 2012). However, a bulk of the literature suggests that as long as there is no severe misspecification problem, stochastic production frontier method is more suitable for efficiency analysis in a developing country agriculture setting where there are serious issues with data quality and accuracy (Coelli 1995). Therefore, based on the dominant discourse in the efficiency debate, this study applies the stochastic frontier approach to assess the efficiency level and identify factors that lead to inefficiency of commercial dairy farms.

3.4.3 Efficiency Estimation

As a result of Farrell's (1957) work, there has been a series of studies in the analysis of efficiencies in all fields. But in the field of agriculture, the modeling and estimation of the stochastic function, originally proposed by Aigneiret al. (1977) and Meeusen and van den Broeck (1977), has proven to be instrumental. A critical narrative of the frontier literature dealing with farm level efficiency in developing countries conducted by Battese (1992), Coelli (1995) indicated that there were wide-ranging theoretical issues that had to be dealt with in measuring efficiency in the context of frontiers and these included: selection of functional forms and the relevant approaches to use.

There are two approaches that can be used in measuring efficiency namely: the parametric and non-parametric models, which differ in two ways. First, they differ on assumptions of the distribution of the error term that represents inefficiency. Second, they differ in the way the functional form is imposed on the data. Parametric methods use econometric approaches to impose functional and distributional forms on the error term whereas the non-parametric methods do not. Nevertheless, parametric models suffer from the same criticism as the frontier deterministic models, in the sense that they do not take into account the possible influence of measurement errors and other noises in the data as do stochastic frontier models. The results can also be misleading because they do not allow for random error as is the case with stochastic parametric approaches. Besides, non-parametric methods also lack statistical tests that would tell us about the confidence of the results. For this reason, this study adopts the stochastic frontier model to measure and explain inefficiencies in dairy farms.

The biggest advantage of the stochastic production frontier models is the introduction of a disturbance term representing noise, measurement error and exogenous shocks that are beyond the control of the production unit in addition to the efficiency component. Hence, Technical efficiency measures obtained from stochastic frontiers are expected to reflect the true ability of the farm given the resources.

The stochastic statistical frontier method requires a prior specification of the functional form, among others, Cobb-Douglas, Trans log, etc. In fact, in this study the Maximum likelihood ratio test was conducted to select the appropriate functional form that best fits the data. The value of the generalized likelihood ratio (LR) statistic to test the hypothesis that all interaction terms including the square specification is equal to zero (HO: βij=0) is calculated as:

LR= -2(LC-LT) …………………………………….………………………… (1)

Where:

LR= Generalized log-likelihood ratio;

L_C= Log-likelihood value of Cobb-Douglas frontier; and

L_T= Log-likelihood β value of Trans log frontier.

This value is then compared with the upper 5% point for the $\chi 2$ distribution and the decision is made based up on the model result. If the computed value of the test is bigger than the critical value, the null hypothesis will be rejected and the Cobb-Douglas frontier production function better represents the production technology of farms.

Variance inflation factor (VIF) was used for checking the presence of a serious problem of multi collinearity and the variables were selected accordingly.

Stochastic frontier is an econometric analytical technique, which allows for variation of output of individual farms from the frontier of maximum achievable level to be accounted for by the farm (Battese, et al., 1997). The model in its implicit form is as follows:

$$Y = f(X_i; \beta) + e_i \text{...} (2$$

$$ei = V_i - U_i \text{...} (3)$$

Where:

- ✓ Y = quantity of output (liter)
- ✓ X_i = vector of the inputs used by the i^{th} farm
- ✓ β = a vector of the parameter to be estimated
- ✓ ei = composed error term
- ✓ Vi = random error beyond the control of farm
- ✓ Ui = technical inefficiency effects
- ✓ f (Xi; β) = appropriate functional form of the vector.

A general Stochastic Frontier Production model following Aigner, et al., (1977) is expressed implicitly as:-

$$lnY_i = \beta_0 + \Sigma \beta_j lnX_j i + V_i - U_i \text{..} (4)$$

The stochastic frontier model for estimating the technical efficiency of dairy farms is specified by the Cobb- Douglas frontier production function, which is defined by:

$$InY_i = \beta_0 + \beta_1 lnOC_i + \beta_2 lnLC_i + \beta_3 lnFS_i + \beta_4 lnFC_i + \beta_5 lnHC_i + \beta_6 lnWE_i + v_i - u_i \text{ ....} (5)$$

Where:-

- ***In* =** Natural logarithm to base e
- **Y_i =** Output of Milk (Liter) in i^{th} farm
- **β_0** = Constant or intercept
- **$\beta_1 - \beta_6$ =** Unknown scalar parameters to be estimated
- **OC_i =** Overhead cost of i^{ith} farm
- **LC_i** = Number of lactating Cows in i^{th} farm
- **FS_i** = Total Farm size of i^{th} farm
- **FC_i =** Feed costs of i^{th} farm
- **HC_i** = Herd costs of i^{th} farm
- **WE_i** = Wealth of the in i^{th} farm
- **v_i** = Random errors
- **u_i** = Technical inefficiency effects predicted by the model

The technical efficiency effect model (Coelli and Battesse; 1995) in which both the stochastic frontier and factors affecting inefficiency are estimated simultaneously is specified as follows.

$$lnY_i = \beta_0 + \beta_1 lnOC_i + \beta_2 lnLC_i + \beta_3 lnFS_i + \beta_4 lnFC_i + \beta_5 lnHC_i + \beta_6 lnWE_i + v_i - (\delta_0 + \delta_1 BM_i + \delta_2 FM_i + \delta_3 MM_i + \delta_4 MF_i + \delta_5 HS_i + \delta_6 EX_i + \omega_i) \quad (6)$$

Where:

Y_i, ln, β_i, OC_i, LC_i, FS_i, FC_i, HC_i, WE_i, v_i and u_i are defined as in equation (4.5)

- **δi = Parameter vector to be estimated**
- **BM_i**= Breeding method of the i^{th} farm
- **FM_i =** Feedig method of the i^{th} farm
- **MM_i =** Milking method of the i^{th} farm
- **MF_i =** Milking frequency of the i^{th} farm
- **HS_i =** Housing system of the i^{th} farm
- **Exi =** Experience of the i^{th} farm
- **ω_i**= Error term; and others are squares and interactions terms

The ML estimates of technical efficiency effects of the model given above would be estimated using a software package ***Stata version 13***. Battese and Coelli (1995) stated that the TE of a farm is between 0 and 1 and is inversely related to the level of the technical inefficiency. Technical efficiency is defined as the ratio of observed output to maximum feasible output. TE_i = 1 shows that the i^{th} farm obtains the maximum feasible output, while TE_i< 1 provides a measure of the shortfall of the observed output from maximum feasible output. It is estimated as; TE_i = Observed Output / Frontier Output

Technical inefficiency = 1 – TE…………………………...………….. (7)

3.4.4 Definition and Measurement of Variables

3.4.2.1. Production Variables

Dependent variable

Output (Y): Total annual milk production by the dairy farm during the 2015/16 production season in liters.

Independent variables

Overhead Cost (OC): This includes labor costs, shed power & heating, dairy supplies, repair and Maintainance, vehicles & registration insurance, taxes of the farm during 2015/16 production season in ETB

Lactating Cows (LC): It refers to number of lactating cows owned by the dairy farm during 2015/16 production season.

Farm Size (FS): Total area of land owned by the farm during the 2015/16 production season in hectares.

Feed Costs (FC): Total cost for fodder, concentrates, supplements and watering of the dairy farm during the 2015/16 production season in ETB

Herd Costs (HC): Total expenditure on artificial breeding, herd testing, animal health and calf rearing of the farm during the 2015/16 production season in ETB

Wealth (WE): Total cost of fixed assets with the exception of land. This variable includes the value of machineries and materials available in the farm during the 2015/16 production season in ETB

3.4.2.2. Variables in the Inefficiency model

Factors included in the model are farm-specific factors that can affect milk production (in) efficiency of dairy farms either positively or negatively. They are specified as follows:

Breeding Method:-

A dummy variable that a value of one if the farm uses artificial insemination for breeding cows. There are many advantages of using AI instead of using natural mating one reason is faster genetic improvement. Besides this AI lessen the risk of spreading diseases between animals. There are reports of up to four times faster genetic progress with AI compared to natural matting (NM) (Van Vleck 1981). Improved genetics are more productive than breeds from natural mating.

Feeding Method: -

A dummy variable equal to 1 for the farm that uses the total mixed ration (TMR) and 0 if the farm uses pasture feeding method. It is believed that TMR feeding is crucial to improve the productivity of the cows thereby the associated efficiency would increase than pasture feeding method. Numerous studies have documented that pasture systems result in lower milk yields because of its negative effect on feed efficiency (Kolver and Muller, 1998; Dartt et al., 1999; Bargo et al., 2002).

Milking Method:-

A set of dummy variables representing each alternative milking system; namely, flat barn, and pit parlor. It is anticipated that farms that use pit parlor as a modern and efficient system of milking as it the latest technology.

Milking Frequency:-

A dummy variable that equals 1 for the farms with a milking frequency more than 2 times per day; It is anticipated that as the milking frequency increases it is expected the efficiency to increase.

Housing System:-

A dummy variable equals 1for farms that use free stall housing and 0 otherwise. A free stall barn is housing system in which cows are "free" to move around to eat, drink and rest wherever they like. These barns provide easy access to feed and clean water, as well as shade and protection from inclement weather which in turn boost the productivity of the cow.

Experience:-

It is a dummy variable that takes 1 for the dairy farms that have above 5 years' experience. It is anticipated that Experience in the dairy farm business is positively related to efficiency. A more experienced farm is able to manage it potential in using his human and material resource efficient which in turn boosts the technical efficiency of production.

CHAPTER FOUR: RESULTS AND DISCUSSION

This part of the thesis presents the results with interpretation and discussion of the findings. Specifically, the first part of this chapter reports the descriptive statistics results. Here the survey data were used to describe the production and efficiency variables used in the study. The second part of this chapter presents the econometric results of the Cobb-Douglas stochastic production function model.

4.1. Descriptive Statistical Results

This section deals with different statistical measures such as mean, standard deviation, minimum and maximum values and percentage comparisons for demographic features, all continuous and dummy variables of interest. Interpretations of the descriptive result are presented as follows:

4.1.1. Analysis Production variables

This subsection presents summary statistics results of production variables (the physical inputs employed in the production of milk output) used for analysis in the stochastic production frontier model.

Table 4.1. **Descriptive statistics of output and input variables (n= 46)**

Variables	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Output Milk (lt)	12,100	75,285	43,692.50	12,521.3
Inputs				
Lactating Cows (in number)	15	52	40.5	3.6
Farm Size (in hectares)	3	9	6.7	0.52
Herd costs (in ETB)	4,842	25,589	15,213.3	102.4
Feed Costs (in ETB))	2,583	13,982	12,473.7	123.54
Overhead costs (in ETB)	120,852	251,832	189,543.03	225.3
Wealth (In ETB)	500,021	80,000,000	537,020.10	236,240.50

Source: own completion result, 2017

Table 4.1 presents summary statistics of production variables. The result of analysis for output variable indicates that on average a farm produced 43,692.50 liters of milk during the 2015/16 production year. The average numbers of dairy cows producing milk at farm level were 40.5 and that ranging from 15 to 52 With a standard deviation of 3.6 the mean number of dairy cows indicates that milk producers own and manage herd sizes, confirming, one of the characteristics of commercial agriculture.

The mean level of farm size used by farms in the study area was found to be 6.7 hectares, the minimum and maximum level of farm size was 3 and 9 hectares respectively with a standard deviation of 0.52 hectares among the farms.

The mean level of overhead costs used by farms in the study area was found to be 189,543.03 ETB, which was obtained by aggregating labor costs, shed power & heating, dairy supplies, repair and Maintainance, vehicles & registration insurance, taxes etc. at the farm the whole year. The minimum and maximum level of overhead cost was 120,852 and 251,832 ETB respectively with a standard deviation of 225.3 ETB among the farms.

The average herd cost was 15,213.3 ETB with 102.4 ETB of standard deviation. It was obtained by aggregating all expenditure on artificial breeding, herd testing, animal health and calf rearing of the i^{th} dairy farm in the 2015/16 production in ETB.

The result indicated that average Feed Cost incurred by farms was about 12,473.7 ETB. It was obtained by aggregating Total cost for fodder, concentrates, supplements and watering of i^{th} dairy farm during the 2015/16 production season in ETB. The minimum and the maximum costs of Feed cost incurred were 2,583 Birr and 13,982 Birr respectively with standard deviation of 123.54 Birr.

The average wealth of farms was 537,020.10 Birr per year with a maximum of 80,000,000 Birr during the production year. The standard deviation amount of wealth that the farms had during the production year was 236,240.50 Birr.

4.1.2. Analysis of Inefficiency variables

This subsection presents the summary statistics of the explanatory variables that were supposed to cause efficiency variations among Commercial dairy farms in the study area. The efficiency variables are dummy variables for better understanding.

Table 4.2. Descriptive summary statistics of inefficiency variables (n= 46)

Dummy Variable	Responses	Frequency	Percentage
Breeding Method	Natural mating (0)	1	2
	Artificial Insemination (1)	45	98
Feeding Method	TMR (1)	43	93
	Pasture (0)	3	7
Milking Method	Flat barn, (0)	38	83
	Pit parlor (1)	8	17
Milking Frequency	2x per day (0)	32	70
	> 2x per day (1)	14	30
Housing System	Free stall (1)	5	11
	Not free stall (0	41	89
Experience	0-5 years (0)	5	11
	Above 5 years (1)	41	89

Source: own completion, 2017

Table 4.2 above presented the summary statistics of dummy efficiency variables. About 98% (45) of dairy farms use the Artificial Insemination breeding method and the remaining uses the natural mating method. From total farms, approximately 93% (43) use TMR feeding method. About 83% (38) of dairy farms used flat barn milking method. The table shows that about 70% (32) of farms milked their cows above 2x per day. With regard to the housing system 11% (5) of the farms used free stall housing system. It is also shown that 89% (41) of the dairy farms have over 5 years' experience

4.2. Econometric Analysis Results

Before proceeding to the estimation of the model parameters, checking whether the stochastic production frontier is more appropriate than a conventional production function, testing whether there exists technical inefficiency in the production process or not and a test was made for multi collinearity among the explanatory variables.

In this analysis individual level of technical efficiency were estimated, the functional form that can better fit to the data at hand was selected by testing the null hypothesis that the coefficients of all interaction terms and square specifications in the trans log functional forms are equal to zero (H0 = βij = 0). The test was made based on the value of likelihood ratio (LR) statistics which can be computed from the log likelihood values of both the Cobb-Douglas and Trans log functional forms using equation (1). Then, the value was compared with the upper 5% critical value of the χ2 at the degree of freedom equals to the difference between the numbers of explanatory variables used in both functional forms (in this case df =15).

In other words, the degrees of freedom are the number of interaction terms and square specifications in the Trans log case restricted to be zero in estimating the Cobb-Douglas functional form. The log likelihood functional values of both Cobb-Douglas and Trans log production functions were -21.5 and -12.3, respectively. The LR value computed therefore was 18.4 and this value is greater than the upper 5% critical value of the χ2 at the degrees of freedom equal to fifteen. This shows that the coefficients of the interaction terms and the square specifications of the input variables under the Trans log specifications were different from zero. As a result, the null hypothesis was rejected and the Cobb-Douglas functional form best fits the data (table 3).

Table 4.3. Hypothesis testing on the Stochastic Frontier Functional form

Efficiency estimation df,0.95a	**Log-likelihood value**	(LR)χ^2calχ^2
H_o**: $\beta_1=\beta_2=\beta_{3\ldots}=0$		
Cobb-Douglas (L_c)	-21.5	
Trans log (L_t)	-12.3	
LR	18.4	15**
sigma^2	.159823	
Sigma v	.1807218	
Sigma u	.3614912	
Lambda (λ)	2.000263	
Gamma ($\lambda^2/(1+\lambda^2)$)	0.83	
Number of obs =	46	
Wald chi2 (4) =	206.91	
Prob> chi2 =	0.0000	

Source: Model output, 2017

The second hypothesis is checking whether the stochastic production frontier is more appropriate than a conventional production function, i.e. testing whether there exists technical inefficiency in the production process or not. The test was carried out by estimating the stochastic frontier production function and conducting a Likelihood-ratio test assuming the null hypothesis of no technical inefficiency.

As indicated in table 3 above, the inefficiency component of the disturbance term (u) is significantly different from zero. Therefore, the null hypothesis of technical inefficiency (H0: Sigma u=0) is rejected. This indicates that there is statistically significant inefficiency in the data. The lambda (λ) value is also greater than one in all the cases. This is a further indicator of the significance of inefficiency. On top of that, the value of gamma indicates that there is 83% variation in output due to technical inefficiency. This means that technical inefficiency is likely to have an important effect in explaining output among farms.

A test was made for multi collinearity among the explanatory variables using the Variance Inflation Factor (VIF) method. The VIF values of all variables entered in to the model were below ten, which is an indicator for the absence of severe multi collinearity among the proposed explanatory variables given the specification of

Cobb-Douglas functional form. Hence; all inputs are included in the maximum likelihood estimation of production function.

4.2.1. Maximum Likelihood Estimates of Parameters of the Models

As the Table 4 depicts below, the estimated coefficients for the lactating Cows, feed cost, herd costs, wealth are all positive, which confirm that there is a positive relationship between the input used and output produced. In addition the positive coefficients of these variable inputs imply that an increase in quantities of these inputs would result in an increase in output. Even though the sign of farm size is positive it is not a significant input. The coefficient of overhead cost was negative which indicates that, a unit increase overhead cost would likely result in 0.164 reduction of milk output. The estimated coefficient of the stochastic frontier with respect to overhead cost was found to be significant and efficiency effect model as presented below in Table 4.4.

Table 4.4: ML Estimates of the Scholastic Production Frontier Model

Variables	Coefficients	t-ratio
Constant	1.05	1.06
Number of lactating cows	0.708	10.8***
Farm Size	0.159	1.33
Feed Costs	0.121	-1.63*
Overhead Costs	-0.164	-1.63*
Herd Costs	0.363	5.51***
Wealth	0.334	2.56**
Sigma squared	0.159	5.13***
Gamma	0.833	10.2***

Source: own computation result, 2017

Herd cost was significant at 1%; this might be due to the fact that it is a major type of input in the sense that it improves the productivity of cows thus leading to increased yield. It also showed that wealth was significant at 5%, its significance may be derived from the fact that as accumulation of wealth (Capital) might induce adoption of new technologies which in turn boost the efficiency.

Finally from Table 4.4, the estimated parameter sigma square (2) = 2 u + 2 v in this study is positive i.e. 0.159 and is statistically/significantly different from 0 at 1% probability level.

The result indicated that we accept the model assumption which signifies that the one-sided error term dominates (about 83.3%) of the variation as it was found to be due to the effects of technical inefficiency in milk production. The symmetric error indicated a good fit which confirms the correctness of the specified distributional assumptions (the appropriateness of using truncated normal distribution for one sided error). This indicates the estimates of frontier production function lie above the traditional average function. In addition, the estimate for the variance parameter gamma value was 0.833 and was statistically significant at 1%. This result suggests that the most important part of the residual variation is due to the inefficiency effect U_i and the random error V_i (i.e., beyond the farms control) has a minor participation.

4.2.2. Technical Efficiency Scores

The mean level of technical efficiency of dairy farms was about 69%, with the minimum and maximum efficiency level of about 40 and 90 %, respectively (Appendix Table). This shows that there is a wide disparity among dairy farms in their level of technical efficiency which may in turn indicate that there exist rooms for improving the existing level of milk production through enhancing the level of farms' technical efficiency.

The mean level of technical efficiency further tells that the level of milk output of the farms can be increased on an average by about 31% if appropriate measures are taken to improve the level of efficiency of dairy farms. In other words, there is a possibility to increase yield of milk by about 31% using the resources at their disposal in an efficient manner without introducing any other improved (external) inputs and practices. The proportion of farms in the efficiency group is shown in Figure 4 below

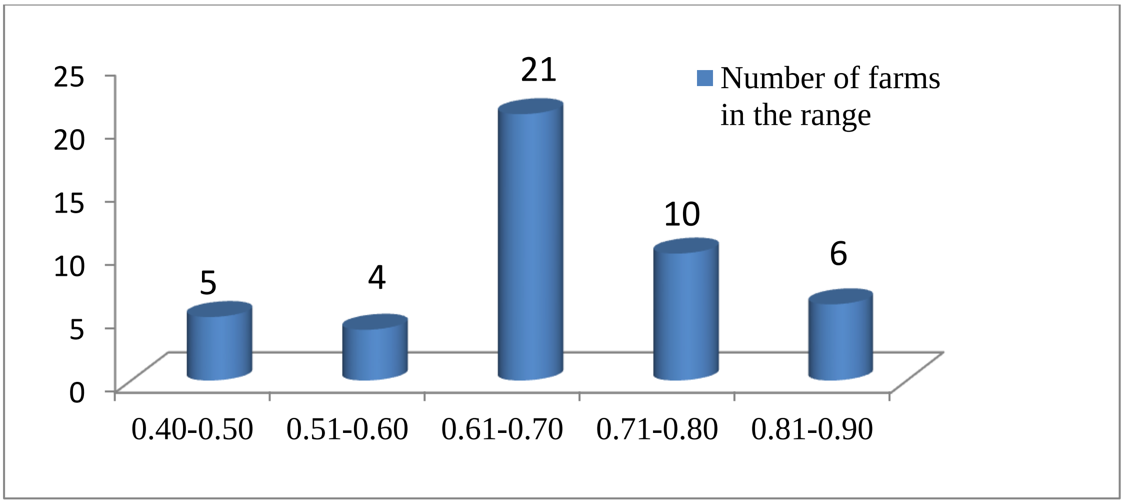

Figure 4.1: Proportion of farms in the efficiency group

Source: Own computation result, 2017

It is observed that about 46% of the farms were operating below the overall mean level of technical efficiency while about 37% of the farms were operating at the technical efficiency level of more than 69%. The result also showed, 17% of the dairy farms were operating at exactly the mean efficiency of 69%. This implies that in the long run improving the existing level of technical efficiency of farms alone may not lead to significant increment in the level of milk yield. So in the long run it needs attention at policy level to introduce other best alternative farming practices and improved technologies. The Technical efficiency of farms is shown in table 4.5 below.

Table 4.5: Technical efficiency (TE) Frequencies for Farms in The Study Area

TE Range	Frequency	Percent
0.40-0.50	4	11%
0.51-0.60	5	9%
0.61-0.70	21	46%
0.71-0.80	10	22%
0.81-0.90	6	13%
Total	**46**	**100%**
	TE estimates	
Mean	0.69	
Min	0.40	
Max	0.90	
Standard deviation	0.13	

Source: Own computation, 2017

Differences in individual level of efficiencies among these farms were also described by grouping the farms based on the deviation of their efficiency from the mean technical efficiency. Then less efficient farms (operating at less than mean), more efficient farms (operating at more than mean) and moderately efficient farms (operating between the two ranges) were found to be 46, 17 and 37 %, respectively. This implies that the majority of the farms were less efficient.

4.3. Factors Causing Technical Inefficiency in Milk Production

The major interest behind measuring technical efficiency level is to know what factors determine the efficiency level of individual farms. Various hypothesized variables that are expected to determine efficiency differences among farms are estimated using a one-stage estimation procedure. Based on the theoretical reasoning regarding the limitation of two-stage approach, one-stage estimation technique was used in the study.

The coefficients of inefficiency variables included in the model were estimated simultaneously by the MLE procedure using the estimated level of TE as dependent variable. Since the dependent variable of the inefficiency function represents the mode of inefficiency, a negative sign on an estimated parameter implies that the associated variable had a positive effect on efficiency, and a positive sign indicates that the variable had a negative effect on efficiency. The interpretation of the variables entered into the inefficiency model is presented in Table 4.6.

Table 4.6: ML Estimates of the Inefficiency Model

Variables	Marginal Effect	Standard Errors
Constant	0.1094	0.3868
Breeding Method	-0.011**	0.005
Feeding Method	-0.332***	0.125
Milking Method	-0.219	0.076
Milking Frequency	0.173**	0.076
Housing System	-0.225	0.082
Experience	-0.002**	0.011
sigma-squared	0.0586	0.0315
Gamma	0.8989	0.0847

*** Significant at 1%, ** significant at 5%, * significant at 10% level of significance

Source: own computation, 2017

The technical inefficiency factors estimated by the model revealed that breeding method, feeding method, milking method, housing system and experience of the dairy farm are found to be significant in explaining the determinants of efficiency (Table 4.6). As these variables are the determinants of inefficiency their sign should be interpreted carefully.

The negative and significant coefficient of breeding method, feeding method, milking method, housing system and experience imply that these variables affect the level of efficiency positively. As these variables are affecting efficiency level positively, the probability of efficiency of farms would improve. On the contrary, the positive sign of milking frequency shows that these variables would affect the efficiency level negatively. Even though milking method and, housing system are not significant, these variables have positive relationship with efficiency. The effect of each variable in the inefficiency model on technical efficiency are discussed below.

Breeding Method: It was hypothesized that farms that use AI breeding method are more efficient than farms that use natural mating as a breeding method. Breeds from AI are believed to be genetically improved which makes them more efficient than breeds from natural mating as this method (NM) increases herds exposure to diseases. The result shows breeding method measured in terms of dummy is found to determine the efficiency level of farmers in producing milk positively and significantly. A simple comparison of mean efficiency level of the two groups in Table 4.7 indicates that farms that use artificial insemination (AI) are 11% more efficient than farms that use natural mating breeding method.

Table 4.7: Technical Efficiency and Breeding Method

Breeding Method type	N	mean TE	Std. deviation
Natural mating	1	0.63	0.24
Artificial Insemination	45	0.74	0.17

Source: own computation result, 2017

Feeding Method: According to Derib (2010) no dairy cow, no matter how good is the breed, cannot be productive without proper management of feeding. TMR feeding strategy blends all feed stuffs into a balanced ration with the required level of nutrients. It was believed that TMR feeding is crucial to improve the productivity of the cows thereby the associated efficiency would increase than pasture method. Numerous studies have documented that pasture method result in lower milk yields because of its negative effect on feed efficiency (Kolver and Muller, 1998; Dartt et al., 1999; Bargo et al., 2002). As discussed earlier, the marginal effect of this dummy variable feeding method shows that if the farm uses TMR, the technical efficiency score would increase by 0.332 in the study area.

Table 4.8: Technical Efficiency and Feeding Method

Feeding Method	N	mean TE	Std. deviation
TMR	43	0.72	0.18
Pastures	3	0.65	0.24

Source: own computation result, 2017

By comparing the mean efficiency level of the two groups in table 4.8 above, it can be concluded that farms that used TMR feeding method are 7% more efficient than farms that used pasture method.

Milking Method: As indicated in table 4.9, the set of dummy variables included to measure the influence of the milking systems on TE was not statistically significant, suggesting that there are no significant differences in TE between the 3 studied parlor technologies (i.e., flat barn, pit parlor, and pipeline). We would expect that pit parlor, a technology associated with modern dairy practices (Wagner et al., 2001; Wronski et al., 2007), would show higher TE over older systems such as pipeline or flat barns.

Table 4.9: Technical Efficiency and Milking Method

Milking	N	mean TE	Std.
Flat bar n	38	0.70	0.05
Pit parlor	8	0.71	0.01

Source: own computation result, 2017

Milking Frequency: It is frequency of milking (number of milking per day). It was believed that as the milking frequency increases the associated efficiency would increase. But the study revealed that the opposite is true in the study area. Based on the result, milking of cows more than 2 times per day affect the level of TE negatively. As table 4.10 presented below, farms that milked their cows above 2 times per day are less efficient (0.58) than farms that milked their cows below 2 times per day (0.72).

Table 4.10: Technical Efficiency and Milking Frequency

Milking frequency	N	mean TE	Std. deviation
2 times per day	32	0.72	0.20
> 2 times per day	14	0.58	0.18

Source: own computation result, 2017

This could be because of the lower capacity of the cow. The result is against the report by Indeed, Erdman and Varner (1994) that stated daily milking frequencies of 3× and 4× have, respectively, 3.5 and 4.9 liter of additional milk produced per day per cow.

Housing system: It was hypothesized that housing system influence efficiency positively. Even if it is positively related to TE, The analysis showed that the type of housing did not have significant effect on TE. As presented in table 4.11 below, the influence of the milking systems on TE was not statistically significant.

Table 11: Technical Efficiency and Housing System

Housing System	N	mean TE	Std. deviation
Free stall	5	0.71	0.03
Not free stall	41	0.70	0.18

Source: own computation result, 2017

It could be argued that free stall housing, a modern dairy farming strategy, may have a positive effect on efficiency because it facilitates herd management and cow comfort. However, farms using a variety of bedded-pack designs as an alternative to free stalls, indicating that these housing systems could be as efficient as free stalls depending on the detailed management provided.

Experience:

It is believed that farms that have much experience in the business are more efficient as they are familiar with the techniques of production and marketing. In line with this, the result table shows that experience variable as measured in terms of dummy is found to affect the efficiency positively and significantly.

Table 4.12: Technical Efficiency and Experience

Experience	Responses	mean TE	Std. deviation
5 Years of experience	5	0.51	0.01
Above 5 years of experience	41	0.68	0.17

Source: Own computation 2017

As the above table clearly shows that, farms that have above 5 years' experience registered a high level of mean technical efficiency than farms that have experience below 5 years.

CHAPTER FIVE: CONCLUSIONS AND RECOMMONDATIONS

5.1. Conclusions

This study examined the technical efficiency of milk production of commercial dairy farms in Sululta district, Oromia Regional State of Ethiopia using cross sectional data collected during 2015/16 production season. The SPF model was used to estimate the technical efficiency of milk production of 46 sample commercial dairy farms in the area.

It's clear from the result of the analysis that the variable with the highest effect on production is the number of cows in the farm followed by herd costs, wealth (capital), and farm size and feed costs. Contrary to this, the coefficient of overhead cost is negative. That means a unit increase in overhead cost result in a reduced milk production by 0.164.

From the analysis of variables in inefficiency model, it can be concluded that, breeding method, feeding method, milking method, housing system & experience were affecting the level of technical efficiency positively, of these variable milking method was found to be insignificant. It was well noted from the result that the milking frequency was affecting the TE level negatively and significantly.

The average level of TE was 69%, which suggests that, from a technical standpoint, the opportunity exists to expand milk production using the current level of inputs and the technologies already available in the area by 31%. These results suggest that dairy farms in Sululta can improve their productivity and efficiency if they take advantage of more efficient farm practices.

5.2. Recommendations

Based on the result of the study, the following recommendation are forwarded

1. This study revealed that the number of lactating cows is found to be highly significant hinting that it is as the most critical input to increase milk production and productivity. This indicates that ways still exist to increase milk output by increasing the level of these inputs within the existing level of technology. So that producers and policy makers should use this opportunity to alleviate the existing level of food deficiency & poverty that is to say in designing development policy specifically for improving milk production should not only looked for the introduction and dissemination of new input technologies but also by giving due attention towards improving the existing level of technical efficiency that can lead to increase in productivity without additional inputs.
2. From the result feeding method was affecting the level TE positively and significantly, revealing it is a crucial input that the a farm should use efficiently so we strongly recommend the concerned government body to give the dairy farms the necessary training on the issue.
3. Even though improving the TE of milk production in Sululta is possible, it is questionable whether this level of improvement would make Sululta dairy farms as efficient or competitive as farms in other Ethiopian regions. To answer this question, a study of larger scope will be needed using detailed farm-level information for representative farms in different geographical locations.

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APPENDICES

Appendix 1: Questionnaires for commercial dairy farms in Sululta districts

Section one: Identification

1.	Date of interview (DD/MM/YYYY)	
2.	Name of the interviewer/enumerator	
3.	Name of the Dairy farm	
4.	Kebele (PA) name	
5.	Village (gott/gare) name	
6.	Ownership type of the dairy farm	
7.	Age of the farm/year of establishment	

Section Two: Farm size and Livestock inputs (quantity and price)

8. How much is the total size of the land used by the farm in hectares? ....
9. How much is the wealth or fixed asset apart from land expressed in terms of ETB? ....
10. How many cattle does the farm own in total?

	Number of cattle type	
	Local/indigenous Breed	Exotic/Crossbred
Oxen/steers		
Cows		
lactating cows		
Bulls		
Heifers		
Calves		

11. What is the type of housing system?

1. Free stall
2. Not free stall

12. Method of breeding the farm is using?
    1. Artificial Insemination
    2. Natural Mating

13. What type of feeding method does the farm use?
    1. TMR(Total mixed ration)
    2. Pastures
    3. Others, specify…………………………………………………………

14. Do you give priority for the cows in cattle feeding?
    1. Yes
    2. No

15. Approximately how much money do you spend on the following expenses per month?
    1. Taxation ………………………
    2. Workers salary: ....
    3. Transportation ………………..
    4. Deworming the animals: ....
    5. Veterinary services…………..
    6. AI and breeding: ....
    7. Grass/hay: ………………………….
    8. Cost of supplementary feed (concentrates or industrial bi-products): ………………
    9. Purchased crop residue: ………………………
    10. Renting/lease of grazing land if the land is rented/leased: ……………….
    11. Other expenses: ....

16. Amount and cost of purchased input (for livestock) during the production year

Type of input	Amount purchased during the year (mention the corresponding units)	Total Cost of the input amount
Green Forage		
Hay		
Crop residue		
Grain as feed		
Compound feed		
Urea Molasses		
Molasses		
Bran		
Oilcake		
Salt		
Vaccine		
Drugs		
Artificial		
Bull service		
Veterinary		
Watering and		
Other (specify)		

Section Four: Milk production and income from all sources

17. How many times on average do you milk the cows on one particular day?

1. 2 Times per day
2. Above 2 times per day

18. How does the milking method mostly take place?

3. Flat barn
4. Pit parlor

19. How much liters of milk that the farm got in the production season?

....

20. Do you process milk on the farm?

1. Yes
2. No

21. What type of dairy products the farm is producing?

1. Milk
2. Butter
3. Cheese
4. Yoghurt/ergo
5. All

6. Others specify...

22. Approximately how much money does the dairy farm make from selling milk and other dairy products in a year? ....

23. According to you, what are the three most important challenges or constraints to milk production in this District?

    1. ……………………………………………………………………………… ……..………………………………………………………………………… ……………………………..
    2. ……………………………………………………………………………… ……..………………………………………………………………………… …………..………………
    3. ……………………………………………………………………………… ……..………………………………………………………………………… ………………………………………..

24. Do you have any general comments regarding dairy production in this area? . ………………………………………………………………………………..…… ……………………………………………………………………………………… ……………………..

Thank You for your time!

Appendix 2: Factors affecting efficiency of dairy farms

Variables P>/z/	Coefficients	t-ratio	
Constant	1.05	1.06	.000
ln number of lacting cows	0.708	10.8***	.001
ln farm size	0.159	1.33	1.20
ln feed costs	0.121	-1.63*	
ln Overhead costs	-0.164	-1.63*	0.06
ln Herd costs	0.363	5.51***	0.35
ln Wealth(capital)	0.334	2.56**	0.04
$sigma^2$ |	.159823		
sigma_v |	.1807218		
sigma_u |	.3614912		
Lambda (λ) |	2.000263		
Gamma ($\lambda^2/(1+\lambda^2)$)	0.80		
Number of obs =	46		
Wald chi2 (4) =	206.91		
Log likelihood =	21.5635		
Prob> chi2 =	0.0000		

Appendix 3: Technical efficiency estimates of each farm.

1	0.40034580	24	0.68725091
2	0.42875230	25	0.68750034
3	0.43015460	26	0.68798510
4	0.45245380	27	0.68914678
5	0.51890910	28	0.69012315
6	0.51564580	29	0.69026578
7	0.52954210	30	0.70142810
8	0.57554780	31	0.73647850
9	0.58489710	32	0.75124860
10	0.67845037	33	0.76214590
11	0.61228760	34	0.76857140
12	0.62535140	35	0.77142860
13	0.62535480	36	0.77148210
14	0.63500310	37	0.78087340
15	0.67012780	38	0.78214560
16	0.67500000	39	0.79215340
17	0.67694270	40	0.79352860
18	0.68082340	41	0.82000100
19	0.68152430	42	0.86741230
20	0.68254720	43	0.88747580
21	0.68405470	44	0.90000000
22	0.68501240	45	0.90228790
23	0.68609190	46	0.90489470