

**ANALYSIS OF ECONOMIC EFFICIENCY OF WHEAT PRODUCTION:
THE CASE OF ROBE DISTRICT, ARSI ZONE, OROMIA NATIONAL
REGIONAL STATE, ETHIOPIA**

M.Sc. THESIS

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HARAMAYA UNIVERSITY, HARAMAYA

**Analysis of Economic Efficiency of Wheat Production: The Case of Robe
District, Arsi Zone Oromia National Regional State, Ethiopia**

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DEDICATION

I would like to dedicate this Thesis to my Lovely Mother, Fatuma Ahmed!

STATEMENT OF THE AUTHOR

By my signature below, I declared that this thesis is my indisputable work and that all sources of materials used for this thesis have been suitably acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree in Agricultural and Applied economics at Haramaya University and shall be deposited at the university library's to be made available to borrowers under the rule of the library. I gravely declare that this thesis had not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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BIOGRAPHICAL SKETCH

The author was born in Sedika Town, Arsi zone of Oromia National Regional State, in October 1992. He attended his Elementary Education at Gado Goro Elementary School and then joined Sedika Senior Secondary School and then Joined Didea Robe Secondary and Preparatory School for his high school studies. He completed his preparatory class in 2012/13 academic year. After completion of his high school education, he joined Jimma University in September 2013 and successfully completed his Bachelor of Science Study in Agricultural Economics in June 2015.

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ACRONMYS AND ABBREVIATIONS

AE	Allocative Efficiency
CSA	Central Statistical Agency
DEA	Data Envelopment Analysis
DFA	Deterministic Frontier Analysis
DMU	Decision Making Unit
EE	Economic Efficiency
EEA	Ethiopian Economic Association
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
IGC	International Grain Council
LR	Likelihood Ratio
MD	Man Day
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
TLU	Tropical Livestock Unit

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Analysis of Economic Efficiency of Wheat Production: The Case of Robe District, Arsi Zone, Oromia National Regional State, Ethiopia

ABSTRACT

Ethiopia is known to be one of the food insecure countries in the world. One way of solving the food insecurity problem is through enhancement of efficiency in agricultural production in general and in wheat production in particular. This study was conducted with the general objective; of assessing the economic efficiency of smallholder wheat producers in the Robe District of Arsi zone, Oromia Regional State, Ethiopia. Both primary and secondary data sources were used for this study. A total of 203 wheat farmers were selected randomly to collect cross-sectional data in 2018/19 production year. Stochastic production frontier model with Cobb-Douglass production functional form was used to estimate the level of efficiencies. The result of the model indicated that input variables such as land, labor, NPS, seed and organic-fertilizer significantly and positively affected wheat output at different significance levels. The obtained return to scale from summation of Elastilities was 1.56%, which indicated that a one percent increase in all inputs proportionally increase the total production by 1.56% showing an increasing returns to scale. The estimated mean values of technical, allocative and economic efficiencies were 85.8%, 80.3% and 69% respectively, which shows that the presence of inefficiency in wheat production in the study area. The result from the Tobit model showed that farming experience, soil fertility, cooperative membership, crop rotation, plot ownership, extension contact, amount of credit, training and combiner had significant positive effect on technical efficiency while family size in adult equivalent, total landholding, plot distance and method of sowing had a significant negative effect. Allocative efficiency was positively and significantly affected by frequency of extension visit, amount of credit used and nonfarm income but negatively and significantly affected by distance from farmer training center and distance from market. In addition, economic efficiency was significantly and positively affected by frequency of extension visit, amount of credit used, plot ownership and non-farm income, soil fertility and cooperative, but significantly and negatively related with distances from market and farmer training center. Generally attention should be given by government and other concerned bodies on the above mentioned factors to improve the efficiency of wheat farmers.

Key words: Cobb-Douglass, Efficiency, Stochastic Frontier, Tobit, Wheat.

1. INTRODUCTION

1.1. Background of the Study

The agricultural sector has a significant contribution to the Ethiopian economy. It is the second most contributor next to the service which is; agriculture: 34.8%, industry: 21.6% and services: 43.6% as well as the sector also has great share in employment creation with more than 72.7% of total labor force and in foreign exchange earnings; contributes 70% of exports (CSA, 2017; CIA, 2019). The agricultural sector also plays important roles in food security, economic growth, and poverty alleviation. Despite the enormous contribution over the past years, its significance is limited because of various factors and hence it is becoming increasingly difficult to meet the food requirements of the growing population (UNDP, 2016).

The performance of the agricultural sector in Ethiopia is characterized by low productivity or low output per input cost. This leads to increasing poverty and food insecurity of rural poor Ethiopian farm households in the country (Alemayehu, 2012). Based on the grain area and in total production volume wheat is the most important grain in worldwide. Global current wheat production is 757 million tons (FAO, 2018). Based on the modest year on year reductions in both area and average yields, 2018/19 global wheat output is expected to be 2% smaller in 2018/19 and total world consumption is projected 3.1 million tons higher (IGC, 2018).

Wheat (*Triticum aestivum*) is one of the most important cereal crops cultivated in a wide range of agro-ecologies in Africa. Wheat is grown on around 10 million ha in Africa. It is a major staple crop for several countries and an imported commodity in all of Africa. In all African countries, wheat consumption steadily increased during the past 20 years as a result of a growing population, changing food preferences and socioeconomic change associated with urbanization. Africa (IFPRI, 2015).

Ethiopia is the largest wheat producer in Sub-Saharan Africa and has a favorable wheat-growing climatic environment. It is the fourth important cereal crop in the country and predominantly grown by subsistence farmers under rain-fed conditions. Although Ethiopia is the largest wheat

Producer in Sub-Saharan Africa, but it is reliant on foreign wheat imports to satisfy its annual domestic demand (FAO, 2014).

Wheat is cultivated in Ethiopia mainly in Oromia, Southern Nations Nationalities, and Peoples Region (SNNPR), Amhara, Benishangul-Gumuz and Tigray with the yield of 29.71Qt/ha, 26.66 Qt/ha, 25.33 Qt/ha, 24.06 Qt/ha and 19.83 Qt/ha respectively. In the main season (*meher*) of Ethiopia, wheat is the third most important cereal crop cultivated after maize and sorghum; and the fourth in production after maize, sorghum, and teff and about 4.2 million farm households are directly dependent on wheat production. There was a slight change in yield (Quintals/Hectare) of wheat in Ethiopia between the production years of 2016/17 and 2017/18 which is only 2.28% from (26.75Qt/ha to 27.36 Qt/ha). This change is inadequate even as compared to other crops such as sorghum that is increased by 7.96% and maize increased by 7.32% (CSA, 2017/18).

In Oromia region, wheat is the second cereal crop in production next to maize; around 26,699,177.73 Quintals from 898,682.57 hectares of land that gives average productivity (yield) 29.71Qt/ha and about 1.7 million farm households depend on wheat production (CSA, 2017/18).

The contribution of wheat and maize in production and consumption, particularly in terms of their high share in calorie intake, has encouraged a national interest for these crops in terms of technology development and dissemination. Wheat contributes about 21% of calories intake from total cereal consumption (FAO, 2013; Berhane *et al.*, 2011).

Arsi zone is known for its cereal production such as wheat, teff, and barley. Among pulses, horse beans and field peas are grown widely. Other crops include vegetables, fruits, root crops, and stimulants are also grown. Most of the farmers in this zone allocate more of their land for cereal production than other crops (Tolesa, 2015).

Among the zones in Ethiopia, Arsi zone is the second in wheat net-surplus next to Bale zone with production and consumption of 582,393 tons and 321,694 tons respectively that gives 260,699 tons of wheat surpluses. Bale zone produces 439,384 Qt and consumes 148,267 Qt with net-surplus of 291,117 Qt. This is followed by west Arsi zone with a total production of

380,523Qt and total consumption of 212773Qt with net-surplus of 167750Qt and East Gojam zone with a total production of 252799Qt and total consumption of 100084Qt with net-surplus of 152715Qt (CSA, 2014; FAO, 2015).

Robe district is one of the potentials wheat-producing districts in Arsi zone. But the district's populations were food insecure. There are no empirical studies that show whether the existing limited resource and technologies are utilized efficiently or not in the production of wheat. Therefore, it is crucial to increase their volume of production and efficiency at least to secure their food needs. Therefore, this study was intended to measure the economic efficiency of wheat farmers and identify factors affecting it in the study area.

1.2.Statement of Problem

In Ethiopia the demand for wheat has grown significantly over the last decade. It is imported in large volumes, and the government has continuously imported wheat for the last several years. The government subsidizes wheat imports. It sells subsidized wheat to contracted large millers who sell flour to bakeries at fixed prices. The primary goal is to make bread more affordable for the poor. Approximately 25-35 percent of domestic consumption is satisfied by imported wheat with Oromiya accounting for over 50 percent of total production. The Southern Nations and Nationalities People (SNNP) and Tigray account for 13 percent and 8 percent of production, respectively. Given the importance of wheat for food security as well as its increasing import burden the government of Ethiopia gives high priority to increased wheat productivity (World Bank, 2018).

The majority of Ethiopian farmers are small-scale producers: about 94% of Ethiopian farmers depend on not more than 0.5 hectares of land from that only 55% of the land is cultivated or 45% of the total land is uncultivated. According to Sisay *et al.*, (2015) in Ethiopia there is wide cereal yield gap among the farmers that may be linked with many factors like lack of information and knowledge on how to implement new crop technologies, poor management, natural factors and others.

According to CSA (2017/18) reports Ethiopia produces 46,429,657.12 quintals of wheat per year with the yield of 27.36Qt/ha. The estimated wheat yield is the lowest as compared to the top wheat producer of the world; such as China(134 million tons) was the largest producer of wheat, followed by India (98.5million tons) and Russian Federation (85 million tons).

This wheat yield is too low as compared to other Africa countries, wheat yields are 6.7 t/ha in Egypt. 3/5 t/ha in South Africa, and 3.0 t/ha in Kenya. There is wheat production gap in Ethiopia; production is estimated at 4.2 million tons in 2017-18, up from 3.9 million tons in 2016-17 and wheat consumption is 5.95 million tons in 2017-18, up from 5.697 million tons in 2016-1. Wheat imports in 2017-18 are estimated at 1.8 million tons, up from 1.5 million tons in 2016-17. In case wheat consumption exceeds its production which indicates that still, the country has deficient in wheat production to meet the national requirements (CSA, 2017).

There is high wheat yield variation among smallholders in the Arsi Zone. The yield gap is mainly due to socio-economic, farm inputs utilization and institutional service characteristics of the farmers. There are considerable numbers of farmers who get yield much below or above the mean national yield (Tolesa, 2015).

Hence, it is crucial to identify the Demographic, socioeconomic, institutional and farm factors that determine the relatively low and high wheat yield level and economic efficiency among farmers. Therefore, identification of determinant factors for variation of yield and Economic efficiency level among farmers helps for targeted agricultural extension activities and for the successful adoption, promotion an improved agricultural technologies and farming practices. Some of the previous studies on the efficiency of wheat productivity with the exception of (Asfaw *et al.*, 2019; Awol, 2014; Fategn *et al.*, 2017)) deals with only technical efficiency and factor affecting it such as (Asefa, 2016; Hassen, 2016; Wudineh and Endrias, 2015). There is a limited empirical study in Ethiopia; particularly on the estimation of economic and allocative efficiency of wheat farming in Arsi zone. There is no empirical study on all three types of efficiencies in the study area. This study tried to fill the information and knowledge gap related to wheat productivity for policymaking by measuring efficiency and identifying factors that are associated with the inefficiency in wheat production in Robe district.

1.3. Research Questions

The main research questions for this study were:

1. What is the level of technical, allocative and economic efficiency/inefficiency of wheat producer farmers in the study area?
2. Which factors cause the technical, allocative and economic efficiency differentials among of wheat farmers in the study area?

1.4. Objectives of the Study

The general objective of the study is to assess the economic efficiency of smallholder wheat producer farmers in the Robe District.

The specific objectives of the study were:

1. To estimate the level of technical, allocative and economic efficiencies of wheat farmers; and
2. To identify factors that affect technical, allocative and economic efficiencies of wheat production in the study area.

1.5. Scope and Limitations of the Study

The scope of this study only covers the economic efficiency of small-scale wheat producer farmers because it does not look for other Agricultural products rather than wheat. The study was conducted in Robe district as wheat is the main consumable and traded grain product. The communities of this woreda have low improved agricultural technology, the traditional method of production, poor infrastructure. It is obvious in such environment that efficient resource use through technical improvement has much to contribute to improvement in their livelihood. This might call enabling producer's access to information on using resource appropriately. The limitation of this study was related to the type of data collected. The study was mainly based on

the information generated from the sample households surveyed during a single cropping season using cross-sectional data due to the unavailability of panel data and time series data sources at the district level.

1.6. Significance of the Study

Study on economic efficiency has a significant contribution to the Ethiopian economy by converting inefficient farms to efficient farms. Efficiency is a very important factor in productivity growth special in developing economies, where the resource is scarce, and the opportunity to develop and adopt better technology is limited. The presence of the shortfalls of efficiency means not only output can be increased without requiring additional input, but also improvements in production through the introduction of new technology was robust if the efficient problem is alleviated. Thus, attainment of the technical efficiency is necessary to determine the magnitudes the gains that could be obtained by improving performance in agricultural production with a given improved technology and management (Getahun, 2014).

Thus, economic efficiency study is believed to contribute to policy and development programs aimed at pro-poor via providing valuable information to government and donors who are interested to help on wheat production in the study area to provide an opportunity to improve productivity and optimize resource use efficiency in wheat production.

The result of this study was expected to provide basic and key direction for farmers, researchers, government, non-governmental organizations, and other development practitioners in the country in general and the study area in particular. Furthermore, the study was expected to generate an adequate understanding of the issues that might be appropriate for the improvement of the efficiency and identification of factors associated with them. Finally, this study was believed to add to the body of literature on economic efficiency in wheat production in the country.

1.7. Organization of the Thesis

This thesis was organized into five chapters. The second chapter deals with the review of literature that includes a theoretical framework of wheat production and empirical studies made in the country and in other countries. A brief description of the study area and a thorough explanation of the methodologies employed for data collection and analysis were presented in chapter three. Chapter four deals with the results and discussions of descriptive and econometric model results and chapter five presents summary, conclusion and recommendations based on the findings of the research.

2. LITERATURE REVIEW

This part reviews the theoretical, methodological and empirical studies conducted on the technical, allocative and economic efficiency. The theoretical review provides background information and concepts of terms that used to offers a justification for the research problem and used to develop the theoretical framework used in the study. The methodological framework has briefly discussed the ways used to perform study and achieve the research objectives. The empirical literature provides evidence from past studies related to the subject and the gaps to be filled by this study. It also provides insights into main variables and analytical models used in examining and identifying economic efficiency.

2.1. Definition and Basic Concepts of Efficiency

The term productivity and efficiency are used interchangeably but, they are not precisely the same thing. The productivity of the farmer is the ratio of outputs that it produces to the input used. Total factor productivity is a productivity measure involving all factors of production (Coelli *et al*, 1998). However, efficiency is the ratio of the value of output produced to the cost of inputs used. It is also defined as, achieving something with minimum or no wastage of resources. Yield is the ratio of the total production of crops in per hectare basis.

In microeconomic theory, according to (Coelli *et al.*, 1998; Koopmans, 1951) technical efficiency is defined as the ability of a firm to produce the maximum output from a given set of inputs and technology or technical efficiency can be explained as the ability of the producer to minimize input use when they are producing a given level of output. As well as the ability of a decision-making unit (DMU) to obtain the maximum output from a set of inputs (output orientation) or to produce an output using the lowest possible amount of inputs (input orientation). Whereas, allocative (price) efficiency expresses the ability of a firm to use his/her inputs in optimal proportions in light of their respective prices. Allocative efficiency is a measure of how an enterprise uses production inputs optimally in the right combination to maximize profits (Inoni, 2007). Thus, the allocative efficient level of production is where the farm operates

at the least -cost combination of inputs. These two measures are combined to give a measure of economic efficiency. That is economic efficiency is the product of technical and allocative efficiencies (Bravo-Ureta and Pinheiro 1997).

Economic efficiency is achieved when the producer combines resources in the least combination to generate maximum output (technical) as well as ensuring least cost to obtain maximum revenue (allocative) (Chukwuji *et al.*, 2006).

The theory of technical efficiency can be used to describe how a producer can produce maximum feasible output by using the available inputs. It determines whether productivity is efficient or not. Production is said to be technically efficient if it is possible to produce a given level of output with less of at least one input and no more of another. The producers may be inefficient due to the following failing to achieve maximum output from a given level of inputs (technical inefficiency), using inputs in wrong proportional given their prices (allocative inefficiency) (Coelli *et al.*, 2005).

2.2. Approaches of Efficiency Measurement

Basically, there are two approaches in measuring efficiency: input-oriented and output-oriented. Both measures will coincide when the technology exhibits constant returns to scale, but are likely to vary otherwise (Battese, 1992) and the details on both approaches have been given in the following sections.

2.2.1. Input-oriented approach

The original idea of representing the technology in a convex iso-quant is an input-oriented measure of efficiency. Farrell (1957) illustrated the idea of input-oriented efficiency using a simple example of a given firm, which uses two factors of production, capital (K) and labor (L), to produce a single output (Y), and face a production function,

$$Y = F(K, L) \tag{1}$$

Under the assumption of constant returns to scale, where the assumption of constant return to scale helped us to present all necessary information on a simple iso-quant. The input-oriented approach addresses the question "by how much a production unit can proportionally reduce the quantities of input used to produce a given amount of output?" The two factors per-unit output that firm uses can be presented on the two-dimensional input/input space. (Coelli *et al.*, 1998).

The iso-quant SS^* (Figure 1) represents the various combinations of the two input variables that at least a firm might use to produce a unit output. This is an iso-quant that defines the input-per-unit of output ratios associated with the most efficient use of the input to produce the output involved.

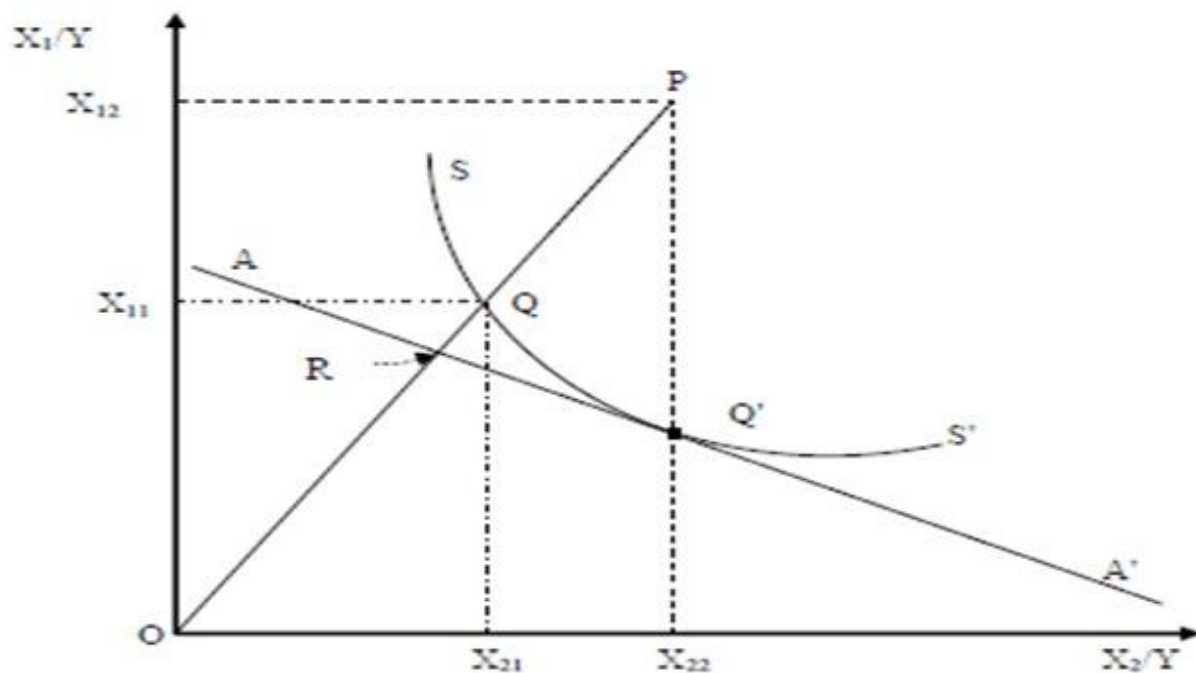


Figure 1: Input-oriented measure of efficiency

Source: Coelli *et al.* (1998)

In an input-oriented measure of efficiency, both allocative and technical efficiencies of a firm fall on or above the unit iso-quant of the input-per-unit of output space and cannot be below or to the left of it. A departure from the unit iso-quant indicates technical inefficiency and the more a firm is far from the unit iso-quant, the more it is inefficient. For instance, as illustrated in

Figure-1 above a firm producing at P uses inputs X_{12} and X_{22} to produce a unit output and a firm producing at Q uses X_{11} and X_{21} amounts of inputs to produce the unit output given by the iso-quant curve SS' .

The ratio $(X_{12} - X_{11})/X_{12}$ which is equal to $(X_{22} - X_{21})/X_{22}$ is the proportion by which firm P has overused the inputs and this measures the level of technical inefficiency of the firm. All firms that are located in the unit iso-quant SS' are technically efficient, and all production inputs are optimally used. On the other hand, allocative efficiency measures the extent to which a firm uses the various factors in the best proportion given inputs and output prices. As a result, technically efficient farms operating at the iso-quant may not necessarily be allocatively efficient, since allocative efficiency requires additional information on both inputs and output prices. The point of tangency between AA' (the iso-cost line) and SS' (the iso-quant curve) is the least cost combination of inputs and thus is the allocatively efficient point of a given firm. Departure from the line AA' represents the degree of allocative inefficiency, and the value for point Q is given by the ratio RQ/OQ . The distance RQ represents the reduction in production costs that would occur if a firm is to produce at both allocatively and technically efficient point Q' instead of at the technically efficient, but allocatively inefficient, point Q. mathematically we can represent the technical efficiency (TE) and allocative efficiency (AE) of a firm operating at P as follows.

$$TE_p = OQ/OP \quad (2)$$

$$AE_p = OR/OQ \quad (3)$$

Economic efficiency (EE) is, therefore, the product of the two efficiencies.

$$EE_p = TE_p * AE_p = (OR/OQ) \times (OQ/OP) = OR/OP \quad (4)$$

2.2.2. Output-oriented approach

While the input-oriented approach answers the question by how much the input use can be reduced without affecting the level of output, in the output-oriented approach one can

alternatively answer the question by how much can the output be increased without increasing the number of inputs used (Coelli *et al.*, 1998).

Figure 2 below illustrates the output-oriented approach of efficiency measurement using a production possibility curve that shows the possible combination of two outputs (Y_1 and Y_2) one can produce given input X and the level of technology.

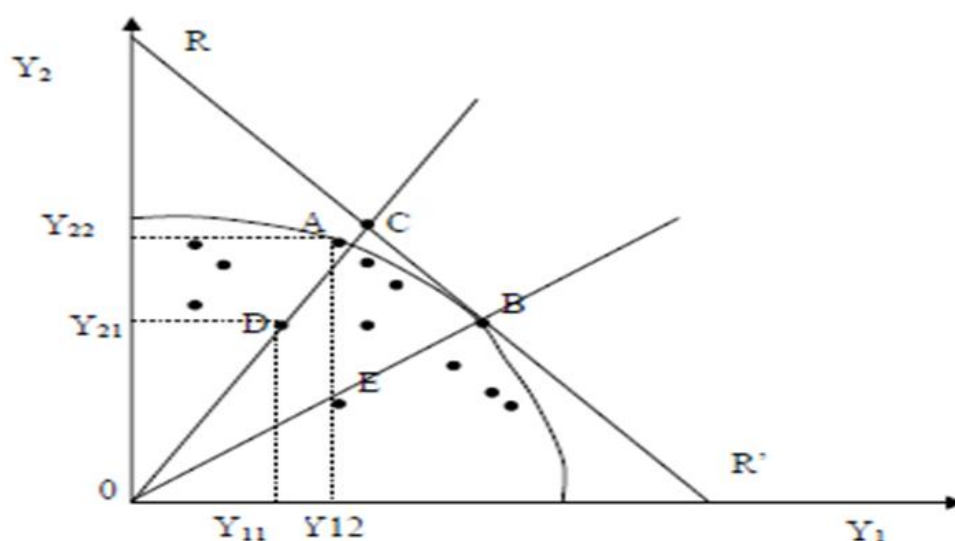


Figure 2: Output-oriented measure of efficiency

Source: Coelli *et al.* (1998)

Given the production possibility curve, a producing unit can then be located either exactly on the production possibility curve or below it. All producers on the curve have attained the maximum combination of Y_1 and Y_2 that can be produced given the input level and state of technology. But firms located below the curve are said to be inefficient. For instance, given the fixed amount of input and level of technology under constant return to scale Firm D is producing lesser amount of both outputs than A. There is a possibility for Firm D to increase the level of outputs Y_1 and Y_2 from Y_{11} to Y_{12} and from Y_{21} to Y_{22} , respectively, without requiring extra inputs. This proportion

$(Y_{22} - Y_{21})/Y_{22}$ which is equal to $(Y_{12} - Y_{11})/Y_{12}$ is the level of technical inefficiency of firm D, and thus the technical efficiency of D is given by:

$$TE = (1 - (Y_{12} - Y_{11})/Y_{12}) = OD/OA \quad (5)$$

We can also define the concept of allocative efficiency using the output-oriented approach if we have the price information of the two products by drawing the iso-revenue line RR' . According to the neoclassical concept, those firms whose marginal rate of substitution between product Y_1 and Y_2 , $\Delta Y_2/\Delta Y_1$, is equal to the slopes of the iso-revenue line are producing the output proportionally considering their prices (Heady, 1952).

The allocate inefficiency is given by the ratio of the distance between the production possibility curve and the iso-revenue curve to that between the origin and the iso-revenue curve. The Allocative efficiency of firm A, for instance, is

$$AE_A = OA/OC \quad (6)$$

The allocate efficiency of all those firms on line OB is equal to one. We can also measure the economic efficiency of a firm as a product of both the allocative and technical efficiencies of the output-oriented approach as follows.

$$EE = (OD/OA) * (OA/OC) = OD/OC \quad (7)$$

Taking the two approaches assumption the attention of farmers in the study area were shifted to output increment than input minimization. So this study was analysis the output oriented approaches of efficiency measurement.

2.3. Models for Estimating Efficiency

Since the groundbreaking work of Farrell (1957), there have been many developments and refinements in the methodology of efficiency measurements. There are also controversial issues as to the efficiency of different methodologies in measuring the technical efficiency of the sector and individual firm and farm-specific inefficiency measurements. Many

comparative studies (Battese and Broca, 1996) and others tried to refine and evaluate specific methodological issues. The frontier methodologies have been widely used in applied production analysis. Technical efficiency measurements are carried out using frontier methodologies, which shift the average response functions to the maximum output or the efficient firm. These frontier methodologies are broadly categorized under two frontier methodologies; parametric and non-parametric frontier models. The parametric frontier model may further be classified into deterministic and stochastic frontier models. The parametric models are basically estimated based on econometric methods and the non-parametric technical efficiency model, often referred to as the Data Envelopment Analysis (DEA), involves the use of linear programming method to construct a non-parametric' piece-wise' surface (or frontier) over the data (Coelli *et al.*, 1998).

2.3.1. Non-parametric frontier models

An alternative method of analyzing efficiency, which has been used in empirical studies, is a non-parametric method. Any non-parametric model, as opposed to parametric models, doesn't require assumption as to the distributional behavior of the population. The principal and most commonly used a model in the analysis of efficiency is data envelopment analysis (DEA). Consequently, DEA model doesn't require any distributional assumption as parametric (deterministic and stochastic) frontier models do. The DEA frontier is both non-parametric, non-stochastic since it does not impose any a priori parametric restrictions on the underlying frontier technology because doesn't necessitate any functional form to be specified for the frontier methodology and doesn't require any distributional assumption for the technical inefficiency term. Therefore, the method avoids the imposition of unwarranted structures on both the frontier technology and the inefficiency component that might distort the measurement of efficiency (Fare *et al.*, 1985). The minimum assumptions required for DEA frontier methodology are monotonicity and convexity of the efficient frontier (Banker *et al.*, 1984). The below DEA model can be presented in Figure 3. Firms operating on the frontier, point C and D are efficient firms while point B and A are inefficient firms. The magnitude of efficiency for point B is OB'/OB , i.e. firm B can reduce both inputs by $BB'/OB * 100\%$.

production frontier analysis. Most researchers, among others Coelli *et al.* (1998), Thiam *et al.* (2001) and others agree that stochastic frontiers are likely to be more appropriate than DEA in agricultural applications of efficiency analysis.

2.3.2. Parametric frontier models

Parametric approaches to efficiency measurement explicitly take into account the existence of production inefficiencies, similarly to DEA, but, also, they make certain assumptions about the nature of the best practice technology. The parametric frontier model can further be classified into deterministic and stochastic frontier methods. The deterministic model assumes that any deviation from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise.

2.3.2.1. Deterministic frontier model

Aigner and Chu (1968) considered the estimation of the parametric frontier production function of Cobb-Douglass form, using data on a sample of N firms defined as follows:

$$\ln(Y) = \chi_i \beta - u_i \quad i = 1, 2, 3, \dots, N \quad (8)$$

Where i - is the number of firms

$\ln(y)$ is the natural log of the (scalar) output of i^{th} firm

X_i -is a $(K+1)$ row vector whose first element is “1” and the remaining elements are the logarithms of the K -input quantities used by i^{th} firm;

$\beta = (\beta_1, \beta_2, \beta_3, \dots)$ is a $(k+1)$ -column vector of unknown parameters to be estimated; and

U_i - is a non- negative random variable associated with technical inefficiency in Production of firms in the industry involved.

Hence, the ratio of the observed output for the i^{th} firm, relative to the potential output Defined by the frontier function, given the input vector, x_i , is used to define the technical efficiency of the i^{th} firm: The primary criticism of the above deterministic frontier model is that

no account is taken of the possible influence of measurement errors and other noise upon the frontier (Coelli *et al.*, 1998).

The deterministic model assumes that any deviation from the frontier is due to inefficiency. Hence, when there is a high random error on the data or where there are few outliers, the inefficiency estimates will be exaggerated as compared to other models, which take into account random errors. In general, most empirical studies on technical efficiency analysis in agriculture used stochastic frontier model due to the very nature of the agricultural output, which is affected by the natural hazard, climatic condition and measurement errors that could attribute to the presence of noise in the data.

2.3.2.2. The stochastic frontier function

The approach is measuring efficiency based on the econometric estimation of a production function that explicitly includes an inefficiency component. This method assumes a specific type of production function. The stochastic production model represents an improvement over the traditional average production function and over the deterministic functions, which use mathematical programming to construct production frontiers. The notion of a deterministic frontier shared by all firm ignores the possibility that a firm's performance may be factory entirely outside its control such as bad weather and input supply breakdowns as well as by factors under its control (i.e., technical inefficiency). To include the effects of exogenous shocks, both favorable and unfavorable, together with the effects of measurement errors and inefficiency into a single one-sided error term, and to label, the mixture inefficiency is a problem with the deterministic frontiers. The agreements lie behind the stochastic frontier (also called composed error) model developed independently by Aigner *et al.* (1977). The essential idea behind the stochastic frontier model is that the error term is composed of two parts. An asymmetric component permits random variation of the frontier across firms, and captures the effects of measurement error, other statistical noise, and random shocks outside the firm's control. A one-sided component captures the effects of inefficiency relative to the stochastic frontier. The stochastic production function considered is defined as (Battese, 1992):

$$Y_i = f(X_i; \beta) \exp(\varepsilon_i) \quad (9)$$

Where y_i is the total output of the i^{th} firm ($X_i; \beta$) is a suitable function of the inputs vector X_i ; β is a vector of unknown parameters, and ε_i is random variable whose distributional properties are defined below. The residual random variable ε_i , in the production function of equation (8) is defined by:

$$\varepsilon_i = v_i - u_i \quad (10)$$

Where v_i is assumed to be independently and identically distributed as a normal random variable with mean zero and variance σ_v^2 [i.e., $\sigma_v^2 \sim N(0, \sigma_v^2)$], and independent of the u_i , which are assumed to be non-negative truncations of the normal distribution with mean, u , and variance,

σ_u^2 [i.e., $\sigma_u^2 \sim N(0, \sigma_u^2)$], and v , u , σ_v^2 , σ_u^2 are unknown parameters to be estimated. Explain output from the frontier which can contribute to technical inefficiency and lies between zero and one. The estimates of u_i and v_i can be obtained by replacing ε_i , δ and γ by their estimates. Hence, individual technical efficiency can be measured as $TE_i = \exp(-E(u_i/\varepsilon_i))$ which represents the level of TE of the i^{th} firm relative to the frontier firm. The measurement of technical, allocative and economic efficiency can only be handled, in a stochastic frontier frame work, through the efficiency decomposition technique. The stochastic efficiency decomposition methodology was proposed by Bravo-Ureta and Rieger (1991), which was an extension of the model introduced by Kopp and Diewert (1982) to decompose cost efficiency into technical and allocative efficiency measures. Stochastic efficiency decomposition is based on the duality between production and cost functions. Bravo-Ureta and Rieger (1991) utilize the level of the output of each firm adjusted for statistical noise, observed input ratios, and the parameters of the stochastic frontier production function to decompose overall efficiency into technical and allocative efficiency. The parameters of the stochastic frontier production function are used to derive the parameters of the dual cost function. The firm's technology is represented by the stochastic frontier production function as follows:

$$Y_i = (X_i; \beta) + e_i \quad (11)$$

Where Y_i = the output of the i^{th} farmer, X_i = a vector of input quantities of the i^{th} farmer, and β = a vector of unknown parameters to be estimated. $e_i = (V_i - U_i)$ the V_i are assumed to be independent and identically distributed $(0, \sigma_v^2)$. The u_i are nonnegative technical inefficiency

effects representing management factors and are assumed to be independently distributed with mean u_i and variance σ^2 . The i^{th} farm exploits the full technological production potential when the value of U_i comes out to be equal to zero, and the farmer is then producing at the production frontier beyond which he cannot produce. The greater the magnitude of u_i from the production frontier, the higher the level of inefficiency of the farmer.

The maximum likelihood estimation of provides estimators for the *beta* coefficients. The variances of the random errors σ^2_v and those of the technical and allocative inefficiency effects σ^2_u and overall variance of the model σ^2 are related; thus, the ratio $\gamma = \sigma^2_u / \sigma^2$ measures the total variation of output from the frontier which can be attributed to technical or allocative inefficiency (Battese and Corra, 2005). If v_i is now subtracted from both sides of equation (11), we obtain

$$y_i^* = f(x_i; \beta) - u_i = y_i - v_i \quad (12)$$

Where Y^* is the observed output of the i^{th} firm, adjusted for the stochastic noise captured by V_i . u and v are inefficiency and random components of overall deviation from stochastic frontier respectively. For a given level of output Y^*i , the technically efficient input vector for the i^{th} firm, X^ti , is derived by simultaneously solving (11) and the ratios $X_1/X_i = k_i$ ($i > 1$) where k_i is the ratio of observed inputs X_1 and X_i .

For this study; from the two models used to estimate efficiency; parametric approach of the stochastic frontier production model proposed by Battese and Coelli (1995) in accordance with the original models for Aigner *et al.* (1977), and Meesuen and van den Broeck (1977) was applied to cross-sectional data to analyze the efficiency of the farmer. In reality the farmer may deviate from the frontier not only because of measurement error, statistical noise or any other influence but also because of inefficiency. in order to draw economic interpretation of analysis results easily, to incorporate both inefficiency and random noises in to the model, to easily identify the contribution of random noises and inefficiency for the deviation from the frontier and to easily and clearly draw economic interpretation of the analysis results a stochastic frontier model is preferred because of its capable of capturing measurement error and other statistical noise manipulating the shape and position of the production frontier.

2.4. Estimation Approaches of Inefficiency Variables

There are two approaches to analyze demographic, socioeconomic, institutional and other farm related factors that determine technical inefficiency. They are one-stage and two-stage estimation approaches. One-stage estimation approach investigates the parameters of the frontier production function simultaneously with various socioeconomic variables of technical inefficiency (Battese and Coelli, 1995). The technical inefficiency variance function can be specified

$$Y_i = f(\beta_i; X_i) + V_i - (\delta_i Z_i) \quad (13)$$

Where Y_i is the output, X_i is the inputs for the production function and β_i is the coefficient of parameter estimate of input variables. Z_i is a vector of explanatory variables and δ_i is a vector of unknown parameters to be estimated for the inefficiency variable.

In the two-stage estimation approach first, the efficiency scores are estimated by using the first stage approach which is the frontier model. Second, efficiency scores are regressed against a number of explanatory variables that are hypothesized to affect technical, allocative and economic efficiencies or inefficiencies by using ordinary least square methods or Tobit regression.

$$Y_i = f(\beta_i; X_i) + V_i - (\delta_i Z_i) \quad (14)$$

$$\mu_i = \delta_i Z_i + e_i \quad (15)$$

Where μ_i is technical inefficiency scores

Since, it is difficult to estimate allocative and economic inefficiency variables with cost and production function of wheat output simultaneously; for this study; Single stage estimation approach is used for production variables and two-stage for inefficiency variables. In which technical efficiency was estimated by using single stage estimation approach and allocative and economic efficiency derived from optimization problem. Then two-stage estimation approach was employed. Incase result of efficiency score obtained in first stage regressed by using tobit model.

2.5. Functional forms of Production Function

The Estimation of the SPF requires a particular functional form of the production function to be imposed. A range of functional forms for the production function frontier are available, such as: Cobb-Douglass (linear logs of outputs and inputs), Quadratic (in inputs), Normalized quadratic and Trans-log production function. From these the most frequently used were a trans-log and Cobb-Douglass functional form of production.

2.5.1. Cobb- Douglass production function

The Cobb-Douglas form was developed and tested against statistical evidence by Charles Cobb and Paul Douglass during 1927–1947 which is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by those inputs. The standard form of Cobb-Douglas function with a single good and two factor inputs are represented as:

$$Y = AL^{\alpha}K^{\beta} \quad (16)$$

Where, Y is the total production (the real value of all goods produced in a year)

L = labor input (the total number of person-hours worked in a year)

K = capital input (the real value of all machinery, equipment, and buildings)

A = total factor productivity and α and β are the output elasticity's of labor and capital, respectively.

Output elasticity measures the responsiveness of output to a change in levels of either labor or capital used in production. The production function has constant returns to scale, meaning that doubling the usage of capital K and labor L will also double output Y . If $\alpha + \beta < 1$, returns to scale are decreasing, and if $\alpha + \beta > 1$, returns to scale are increasing.

2.5.2. Trans-Log production function

The first form of trans-log production may be considered the proposal made in 1967 by J. Kmenta for the approximation of the CES production function with a second order Taylor series, when the elasticity of substitution is very close to the unitary value, which is the case of Cobb-Douglas production function. After that there were improvements and model development by scholars such as, Grilichs and Ringstad proposed new forms of production function and Sargant also was called a log-quadratic one in 1971. Transcendental logarithmic production function “was proposed by Christiansen, Jorgensen and Lau in two papers published in 1971 and 1973, which dealt with the problems of strong additive and homogeneity of Cobb-Douglas and CES production functions and their implications for the production frontier. The generalized form of trans-log functional form was;

$$\ln Y_i = \ln \beta_0 + \sum_i^n \beta_i + \ln x_{ik} + 1/2 \sum_{i=1}^n \cdot \sum_{i=1}^n \cdot \beta_j * \ln x_{ik} * \ln x_{jk} + e_i \quad (17)$$

2.5.3. Theoretical comparisons of production functional form

One of the procedures of econometrics Analysis is the selection of best fitted functional forms. Each functional form has its own advantage and disadvantage. Some researchers argue that Cobb-Douglas functional form has advantages over the other functional forms in that it provides a comparison between adequate fit of the data and computational feasibility. It is also convenient in interpreting elasticity of production and it is very economical with respect to degrees of freedom. So nowadays, it is widely used in the frontier production function studies (Hazarika and Subramanian, 1999).

In addition, due to its simplicity features, the Cobb Douglas functional form has been used in most empirical estimation of frontier models. This simplicity however, is associated with some restrictive features in that it assumes constant elasticity, constant return to scale for all firms/farms and elasticity of substitution are equal to one (Coelli *et al.* 1998).

Moreover, several studies specifically farm efficiency studies, from both developing and developed countries, have used the Cobb-Douglas functional form despite its limitations (Battese, 1992). On the other hand, the translog functional form imposes no restrictions upon returns to

scale or substitution possibilities. However, the problem of degrees of freedom and multicollinearity is a serious problem in translog production function (Coelliet *al.*, 1998).

By taking the merit and demerit of both functional forms into consideration, in this study from the two of production frontier functional forms; based on the likelihood ratio test result, Cobb-Douglas functional form was well fitted of data and implemented for this study.

2.6. Empirical Review on Technical, Allocative and Economic Efficiency

Stochastic production frontier approach with Cobb-Douglas functional form and two limit Tobit model was fitted to analysis production variables and inefficiency factors respectively. From input variables mineral fertilizers, land and seed had significant positive effect to rise the quantity of wheat output. The estimated mean values of technical, allocative and economic efficiencies were 78, 80 and 63% respectively. Result from two-limit tobit model indicated that technical efficiency positively and significantly affected by sex of the household head, education, extension contact, off/non-farm activity and soil fertility but negatively affected by land fragmentation. Similarly, age, education, extension contacts and off/non-farm activity positively and significantly affected allocative efficiency. In addition, economic efficiency positively and significantly affected by sex, age, education, extension contact, off/non-farm activity and soil fertility (Asfaw *et al.*, 2019).

One stage stochastic frontier of Cobb-Douglass functional form was employed to estimate technical efficiency and to identify factor casing technical inefficiency. The estimated stochastic production frontier model indicated that input variables such as land size, fertilizer (Urea and DAP), human labor, oxen power and chemicals were found to be important factors in increasing the level of sorghum output. The estimated mean levels of technical efficiency of the sample households was about 69% and the discrepancy ratio of 90%. Education level, family size, non-farm activities, extension contact, and soil fertility status were found with positive significant effect in determining the level of technical efficiency of sorghum production but age, livestock holding and plots distance have significant negative effect on technical efficiency of sorghum production (Kusse *et al.*, 2018).

Wollie *et al.* (2018) analyzed the economic efficiency of smallholder farmers in barley production in the Meket district, Amhara National Regional State, Ethiopia. They use cross sectional data with trans-log functional form to estimate both production and cost functions and OLS estimation to identify allocative and economic inefficiencies factors and single stage estimation approach to analysis technical inefficiency factors. They found that; fertilizer, human labor and oxen power as significant variables that increase the quantity of barley output, while barley seed had a negative effect. They get the efficiency score level of 70.9, 68.6 and 48.8% for of technical, allocative and economic efficiencies respectively. According to their findings all of the three types of efficiencies were significantly and positively affected by extension contact and number of barley plots. Whereas distance of residence from the nearest main market was found to have a negative and significant effect on all of the three types of efficiencies.

The maximum likelihood estimates of Cobb-Douglas stochastic production function was used to predict the TE of farmers. The study revealed that statistically significant positive elasticity of ox, labor, seed and urea. The study also found mean score of technical, allocative and economic efficiencies were 77.68%, 49.26% and 37.47% respectively. The study found that age of the household head, education level, family size, off/non-farm income and extension contact contributed significantly and positively to technical efficiency, while it is negatively related with proximity. The allocative efficiency of farm households was positively and significantly affected by off/non-farm income, time of sowing, row planting and proximity to homestead. Economic efficiency of the farm households was positively and significantly affected by time of sowing, off-farm income, and row planting indicating that these variables determine the level of economic efficiency positively. On the contrary, age of the household head, extension contact and credit are negatively related with allocative efficiency and credit and proximity to homestead are negatively related with economic efficiency level (Fategn *et al.*, 2017).

Stochastic production frontier model with Cobb-Douglas functional form was used to estimate technical efficiency and identify the existing relationship between input and output variable and tobit model for identifying inefficiency factors for all of the three types of efficiencies. The estimated result showed that the estimated mean of technical, allocative and economic

efficiencies were 81.78%, 37.45% and 30.62% respectively. The analysis results of the tobit model depicted that, education level of the sample household was the most important factor that found significant to affect the level of technical, allocative and economic efficiency all together. Whereas, land fragmentation and soil fertility were the major factors that affect the level of technical efficiency. Besides, land fragmentation, ownership and frequency of extension contact were important factors that affect allocative efficiency of farmers in the study area. The results also further revealed that extension contact was the most important factor that found to be statistically significant to affect economic efficiency (Mustefa *et al.*, 2017).

Efficiency analysis has been considered by different researchers. In this section, some of related empirical studies on technical, allocative and economic efficiencies are reviewed. Recently, there are a number of studies conducted on, TE, AE and EE using different approaches in modeling frontier production functions such as deterministic and stochastic method and statistical methods and parametric and non-parametric method in Ethiopia and elsewhere.

Ettah *et al.* (2017) conducted their study on Analysis and Determinants of Profit Efficiency of Cassava Farmers in Cross River State, Nigeria. They used to stochastic frontier profit of Cobb-Douglas functional form. For the determinants of profit efficiency, the minimum and maximum profit efficiency was 0.14 and 0.91 respectively with mean profit efficiency of 0.65. The mean profit efficiency implies that farmers were able to obtain 65% of their potential profit from a unit mix of inputs.

According to the study by Isitor *et al.* (2017) on the analysis of technical efficiency of smallholder cassava farmers in Nigeria indicate that, the result from Maximum Likelihood Estimates of the production function shows the technical efficiencies of the farmers were found to be low with an average of 51.5% which implies that average cassava output fell short by 48.5% of the maximum possible level. The study further reveals that only education and access to credit are the factors that significantly influenced technical inefficiency of cassava farms in the study area.

The study by Nwike *et al.* (2017) examines the economic efficiency, determinants of efficiency, returns to scale and constraints to cassava production. The Results from parametric statics indicated that maximum, minimum and mean economic efficiency scores of 0.85, 0.48 and 0.76

respectively for all farm group. Labor and material inputs significantly determined production output while farming experience, educational attainment, credit accessed, extension visit and age were significant sources of inefficiency. The farm groups operated at increasing returns to scale. Most serious constraints to cassava production in the area were high cost of labour followed by inadequate capital, high cost of fertilizer and agro chemicals, insufficient farm mechanization, poor technical knowledge and crop yield.

Parametric approaches employing stochastic frontier of Cobb-Douglas production function was used in the estimation of technical, allocative and economic efficiencies of farmers whereas two-limit tobit model for identifying factors affecting efficiencies of production. The obtained result indicate that the mean technical, allocative and economic efficiency scores were found to be 62.3, 57.1 and 39 percent, respectively, indicating the existence of substantial inefficiencies in maize production. Technical, allocative and economic efficiencies are significantly affected by family size, education level, extension services, and ownership of mobile phone, cooperative membership, Land holding and livestock holding (Sisay *et al.*, 2016).

Cobb-Douglas was fitted using stochastic production frontier approach and estimates the level of technical, allocative and economic efficiency as 74, 44 and 32 percent respectively. As well as from the result of tobit regression model the variables such as age, sex and Land holding has positive effect on technical efficiency but Land holding and fragmentation affect technical efficiency positively. The study also show that experience and education has positive and significant effect on allocative efficiency while age and sex were found to have significant negative effect. As obtained by this study Land holding has positive and significant effect on economic efficiency whereas land fragmentation and extension contact affect economic efficiency negatively and significantly (Gosa *et al.*, 2016).

Hassen (2016) measure the level of technical efficiency and identify its determinants in wheat crop for smallholder farmers in South Wollo Zone, Ethiopia. He used stochastic production frontier model and the result revealed that the average technical efficiency was 78%. His result also indicate that area allocated under wheat, seed, fertilizer applied and labor in man days were appeared to be significantly influencing wheat production at less than 1 percent probability level.

According to him the socio-economic variables that exercised important role for variations in technical efficiency were age, education, Land holding, and livestock holding in TLU, number of oxen holding, access to irrigation and access to credit. Nevertheless, participation on off farm income, and interaction of off farm income and education was found to decrease efficiency significantly among farm household.

Ermias *et al.* (2015) used stochastic production frontier model to estimate technical, allocative and economic efficiency of sesame producer in selamago district of south Omo zone, Southern Ethiopia. Their study was based on the cross sectional data collected in 2011/12 production season from 120 randomly selected farm households. The results from stochastic frontier analysis showed that the mean technical, allocative and economic efficiencies of sample households were 67.1%, 67.25% and 45.14% respectively. They were used tobit model to identify factors affecting efficiency levels. The result of tobit model revealed that soil fertility, non-farm income and credit access positively and significantly affected technical efficiency. Soil fertility had positive and significant effect on allocative efficiency. On the other hand experience in sesame production, distance of sesame farm from residence, non-farm income and extension contact affected allocative efficiency negatively and significantly. Soil fertility, non-farm income and credit access had positive and significant impact on economic efficiency. However, extension contact affected economic efficiency negatively and significantly.

Musa *et al.* (2015) have made a study on measuring the technical, allocative and economic efficiencies of maize production in the central rift valley of Ethiopia using cross sectional data collected from randomly selected 138 sample households. Among factors hypothesized to determine the level of efficiency scores, frequency of extension contact had a positive relationship with technical efficiency and it was negatively related to both allocative and economic efficiencies. Credit was also found to influence technical and economic efficiencies positively and distance to market affected technical efficiency negatively. The model output also indicated that soil fertility was among significant variables in determining technical efficiency in the study area. The result indicated that there is a room to increase the efficiency of maize producers in the study area. Were estimated using parametric approach employing stochastic

frontier Cobb-Douglas production function, while factors affecting efficiencies of production were modelled using a two-limit Tobit model.

Wudineh and Endrias (2015) assess the technical efficiency and factors affecting efficiency of wheat production in Welmera district of Oromia region, Ethiopia. They used stochastic frontier and translog functional form with a one-step approach was employed to assess efficiency and factors affecting efficiency in wheat production. Their analysis result depicted that, the mean technical efficiency was found to be 57%. Their finding also implies that there is an opportunity to improve technical efficiency among the farmers by 43% through gender-sensitive agricultural intervention, group approach extension, and attention to farmers' education, scaling out of best farm practices.

According to (Awol, 2014) farmers are facing decreasing returns to scale from his result of return to scale of 0.956. which indicate that a 1% simultaneous increase in all inputs at the sample mean will increase wheat output by about 0.956%. The analysis of resource productivity revealed statistically significant positive elasticities of land, labour, fertilizer and oxen and implying that increase in each of these inputs will increase wheat output. The study also found that mean indices of TE, AE and EE were 72.49%, 42.7% and 31.65% respectively. The study found that sex of the household heads, land fragmentation, fertility status of land, slope, credit use, and training obtained and oxen numbers contributed significantly and positively to TE, while it has inverse related with Land holding. The AE and EE of the farm household was positively and significantly affected by sex of the household heads, frequency of extension use, oxen number, family size, slope and training shows that these variables determine the level of efficiency positively. On the contrary, age of the household heads and number of livestock unit have inverse related with AE and EE level.

Kifle (2014) investigated EE efficiency of small holder farmers in maize production in Bako Tibe District, using Cobb-Douglass function form of stochastic frontier model was used to estimate the efficiency of maize production. The estimated frontier model showed that, the mean TE, AE and EE of maize producer farmers were 82%, 66% and 54% respectively. He uses tobit model to identify factor affecting efficiency of maize farmers and found that age, off/non-farm

activities, amount of land owned and perception on agricultural policy had a significant positive effect on TE and sex of household head had less significant effect. Education, frequency of extension visit, perception on agricultural policy and livestock holding had positive significant effect on AE while age of household head, off/non-farm activities, amount of land owned, credit utilized and perception on agricultural policy were found to have positive effect on EE.

Beyan *et al.* (2013) evaluated the technical efficiency of farm production of smallholder farmers in Girawa district using cross sectional data. They implement single stage stochastic production frontier approach having Cobb-Douglass production function, founded that the mean technical efficiency was 81.5%. Moreover they found that the discrepancy ratio (γ) about 75%, which measures the relative deviation of output from the frontier level due to inefficiency. They also indicated that education, livestock holding, extension contact, farmer's training, cultivated area and participation to irrigation were found to determine technical efficiencies of farmers positively while social status had negative relationship with technical efficiency.

Najuma (2012) investigated TE, AE and EE and identified factors that cause a difference in Economic efficiency Potato producing farmers of the shashamane district in West Arsi zone. she uses cross-sectional data from sample 150 households. Cobb-Douglass function form of the stochastic frontier model was used to estimate the efficiency of Potato Production. The estimated frontier model showed that, the mean TE, AE and EE of potato producer Farmers were 74%, 45% and 33% respectively. Among factors forwarded to affect the level of economic Efficiency of potato: age, access to credit, training was found to have a positive and significant impact on the Economic efficiency of potato production.

Stochastic frontier model with Cobb-Douglass functional form employed to estimate the level of technical efficiency and indicate the existing input-output relationship. As well as factor affecting technical, allocative and economic efficiencies were analyzed by using tobit model was adapted by most of efficiency studies reviewed so far (Asfaw *et al.*, 2019; Sisay *et al.*, 2016; Mustefa *et al.*, 2017; Musa *et al.*, 2015; Gosa *et al.*, 2016; Ermias *et al.*, 2015; Sihlongonyane *et al.*, 2014;

Kifle, 2014; Awol, 2014; Fategn *et al.*, 2017). Hence, this study used the empirical studies reviewed so far as a basis to decide up on the input factors to be considered in production function of the model, factors affecting technical, allocative and economic efficiencies of sample households and to choose the methods to be employed.

Cobb-Douglass production function and Tobit regression were used to analyses cross-sectional data. They obtained the mean technical, allocative and economic efficiency of 64.7%, 99.52%, and 64.3% respectively. The result indicate that the farmers were able to use minimum costs to get a given level of output. They were able to use minimum inputs and at minimum costs for a given level of output. However, farmers could still increase their economic efficiency by 35.7%. Technical Efficiency was affected by formal education, household size. Allocative efficiency was affected by formal education and gender whereas Economic efficiency was affected by household size (Sihlongonyane *et al.*, 2014).

Samuel *et al.* (2014) estimated economic efficiency relating to a Land holding of wheat producer for the small holder in Nakuru district Kenya using stochastic frontier production and cost functions. His result shows mean technical, allocative, and economic efficiency indices of small-scale wheat farmers are 85%, 96%, and 84%, respectively, while for the large-scale farmers the mean technical, allocative, and economic efficiency indices are 91%, 94% and 88%. Thus, the results from both small and large scale farmers reveal some considerable levels of inefficiencies in wheat production in Nakuru district. However, the large-scale farms have relatively higher technical and economic efficiencies compared to small-scale farmers.

Ali *et al.* (2012) estimated economic efficiency of wheat and faba bean production for small holder farmers in the northern state of Sudan in Dongola and Ed- abba localities using stochastic frontier production and cost functions. The result shows mean TE of wheat were 0.75 and 0.66 in Dongola and Ed- abba locality respectively while faba bean were 0.65 and 0.71 and the overall mean AE of wheat in two localities were 0.72 and 0.68 where, as 0.86 and 0.84 for faba bean. The overall mean EE that estimated as inverse cost efficiencies of wheat were 0.41 and 0.45 in the two localities. It indicates that the farmers who cultivated faba bean were more economically efficient than farmers who cultivated wheat in the two localities.

2.7. Conceptual Framework of the Study

The performance of agricultural production depends on the improvement of efficiency in production, development and use of cost effective technology which leads to directly by raising production levels and indirectly by reducing poverty through raising incomes of farm households, raising employment, lowering the price of food and there by affecting the food security and wellbeing status of rural households. The efficiency of wheat farm can be affected different factors. These factors can be categorized into five categories.

1. Socioeconomic conditions such as education level of household head, Livestock and participation of farmer on nonfarm or off farm activities like petty trade and other income source for them and system of cropping whether it is row planting or broad band maker.
2. Farm characteristic such as nature of Soil Fertility, Land holding, Land ownership, Time of sowing, Crop rotation and Method of sowing. 3. Production factors such as land, labor, fertilizer, seed, oxen and chemicals. These factors are used as inputs in the production of wheat output and they directly affect the performance of the wheat yield.
4. Institutional factors such as distance from market, accessibility and availability of extension worker and organization like FTC and cooperative leaders for information and 5. Demographic factors like age, sex and family size of farm household. Better performance of all of the above factors leads to technically, allocatively and economically efficient farmer.

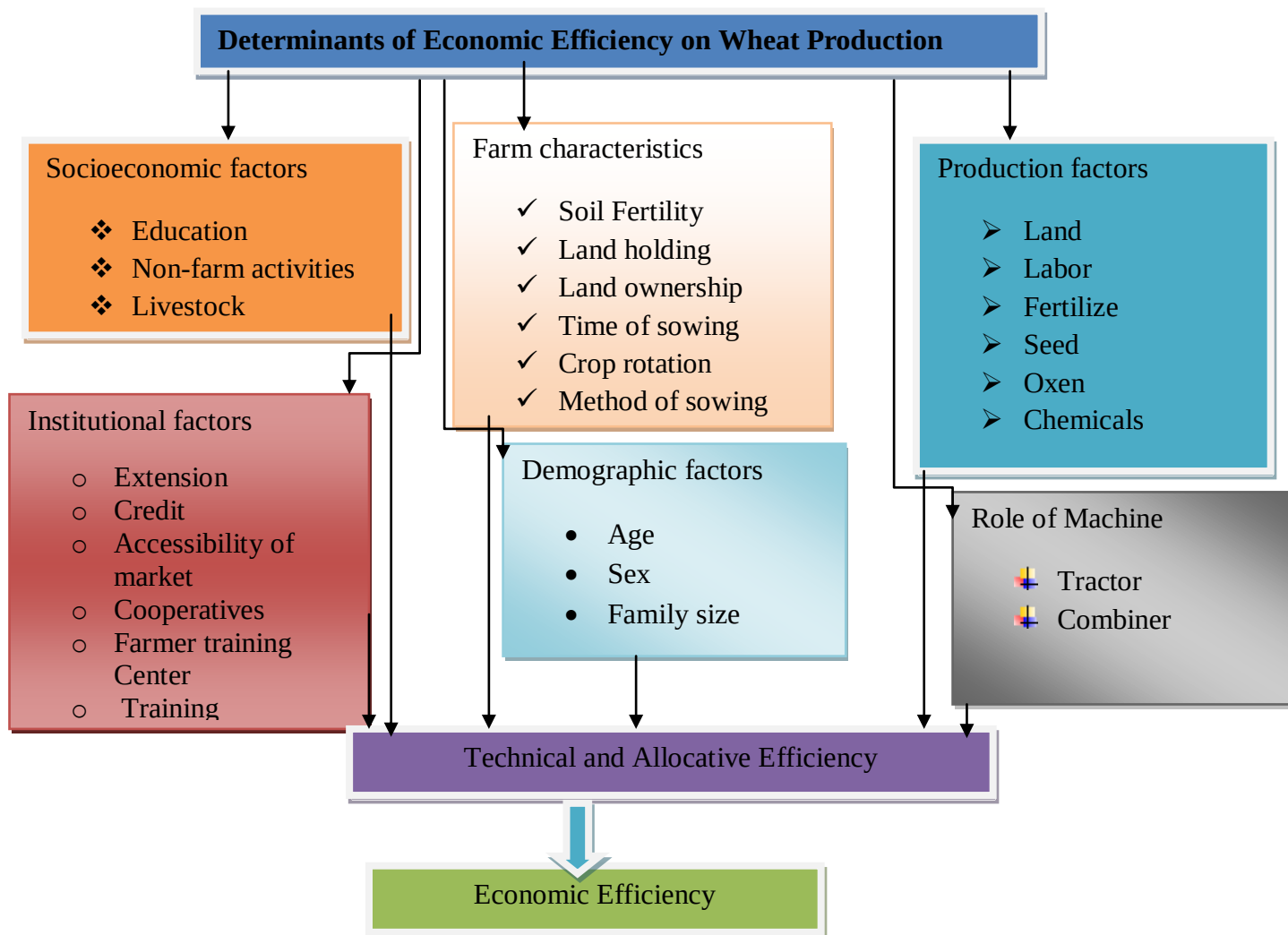


Figure 4: Conceptual framework of the study

Source: Own conceptualization based on literatures (Fategn *et al.*, 2017, Getachew *et al.*, 2018 and Musa *et al.*, 2015)

3. RESEARCH METHODOLOGY

This chapter presents the brief description of the study area, sampling technique, source and method of data collection, method of data analysis like descriptive statistics and econometric models that includes specification of the model, functional forms and hypothesis testing.

3.1. Description of the Study Area

The study was conducted in Robe district Arsi Zone of Oromia Regional State. Robe is located in the southern part of the country. This town has a latitude and longitude of 09°36'N 39°08'E and 09°36'N 39°08'E respectively with an elevation of 2435 meters above sea level. It is found about 225 km southeast of Addis Ababa and 98 km east of Asela (the capital town of Arsi zone). It is bordered by the Shebelle River on the south which separates it from the Bale zone, by Sherka Woreda on the southwest, by Tena Woreda on the west, by Sude Woreda on the north, by Amigna on the northeast, and by Seru on the east. The total area of the woreda is about 1322.5km² and it constitutes 5.3% of Arsi Zone. The altitude of this woreda ranges from 1200 to 4000 meters above sea level. Rivers include 45 kilometers of the Hulull and 40 kilometers of the Wabe; the gorge of the Wabe is a local landmark (EDPPA, 2006).

The main economic activity of the population of Robe Woreda is agriculture with a mixed farming system at subsistence level producing both crops and livestock. More than 90% of the total population depends on subsistence farming as the livelihood strategy. The main source of the income of the study area is obtained from agricultural produce. Sale of crops and livestock products. Besides, non-farming activities such as trade, daily labor, charcoal, and fuel wood selling. However, income obtained from a non-farming activity is limited as compared to farming activities. The woreda is characterized by a shortage of water for drinking, animals, and irrigation. The main crops produced in the Robe woreda where cereals (wheat, *teff*, barley, maize and), pulses (bean, peas, and field pea) and oilseeds (linseed and nug) are grown (CSA, 2017).

Depending on the CSA results of 2013b, the total population of the Woreda is 197,234 person of which 117,742 (90%) of its total population are rural and 19,492 (10%) are urban dwellers. The

number of the male and female population is 99,292 and 97,942 respectively giving a sex ratio of 100 female to 101 males. The average population density of the woreda is 147 persons per km² within an estimated area of 1,338.6 square kilometers. Robe woreda consist people of different ethnic groups. According to Robe meteorological station, the maximum and minimum rainfall is about 1300 mm and 700 mm respectively. The area exhibits a bimodal pattern of precipitation, with the bog rains that constitute about two-thirds of the annual total rainfall amount falling between July and September and the small rains between March and May.

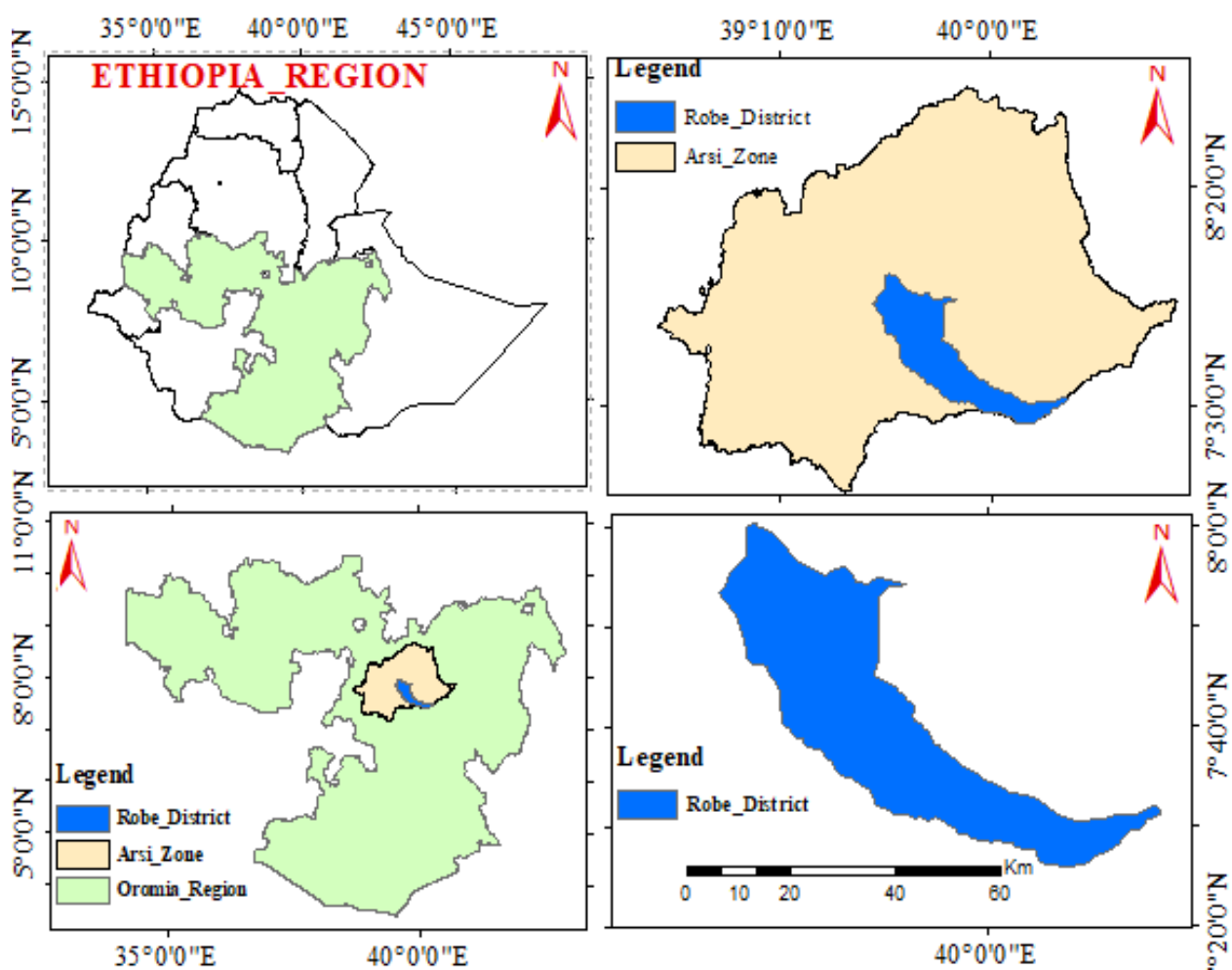


Figure 5. Location map of the study area

Source: Own sketch with the help of GIS expert (2019)

3.2. Data Types, Sources, and Methods of Data Collection

Both qualitative and quantitative data were collected from primary and secondary sources. The primary data were collected from sample farmers by an interview using a semi-structured questionnaire. The secondary data were collected from the woreda Agricultural office and from published and unpublished sources.

3.3. Sampling Techniques and Sample Size Determination

Based on the pre-proposal development information gathered from the woreda experts and agronomy office of Robe district there are no any kebeles that do not produce Bread wheat as well as there is no household head that does not produce Bread wheat. The District has 32 kebeles and all kebeles produce Bread wheat. In order to select sample households; two stages of random sampling procedure was implemented. In the first stage, six kebeles were randomly selected. In the second stage, 203 sample wheat farmers were selected by using simple random sampling technique from each kebele proportional to the total number of the households of that kebele (Table 1).

Table 1. Sample kebeles, total households and sample households

Kebeles	Households	Sample households
Habe Dangazela	1158	38
Sude Waltahi	1085	35
Adamtu Laman	970	31
Gado Goro	965	31
Doyo Gora	904	29
Mesrenje Abbuu	1211	39
Total	6293	203

Source: own computation, 2019

The district's population was homogeneous so the Yamane (1967) formula was adopted for the sample size determination technique:

$$n = N / (1 + N(e^2)) \quad (18)$$

$$n = 29436 / \{1 + [29436 * 0.07 * 0.07]\} = 202.68$$

Where; e is the desired level of precision

$n = (n_1 + n_2 + n_3 + n_4 + n_5 + n_6)$ total number of sampled households from each selected kebele and

N is the total number of households of the woreda

Therefore, by taking e as 7% and N = 29436 the sample size to be selected was 203.

Thus, a total of 203 respondents were selected on a random basis from the sampled of six kebeles in the Woreda.

3.4. Method of Data Analysis

To address the objectives of the study, descriptive and econometric methods of data analysis were used.

3.4.1. Descriptive statistics

In the descriptive part, mean, standard deviation, frequency and percentages were employed to analysis the effect of socioeconomic, institutional factors and input-output variables on the level of efficiency.

3.4.2. Econometrics models

In the econometric analysis, a stochastic production frontier approach was implemented to estimate the level of technical, allocative and economic efficiencies in wheat production and the factor affecting the level of all types of three efficiencies were analyzed by using the Tobit model.

3.4.2.1. Specification and Structure of the model

From the approaches used to measure efficiency, stochastic production frontier (SPF) approach and data envelopment analysis (DEA) were widely used approaches. Taking their assumptions on different efficiency analysis models discussed so far in the analytical framework of the study, in order to draw economic interpretation of analysis results easily, to incorporate both inefficiency and random noises in to the model, to easily identify the contribution of random noises and inefficiency for the deviation from the frontier and to easily and clearly draw economic interpretation of the analysis results, two-stage SPF model was used for this study. The stochastic frontier production function of Cobb-Douglas type is defined in logarithmic forms. This is represented in Equation (19).

$$\ln(\text{Output}) = \beta_0 + \beta_1 \ln(\text{Ox}) + \beta_2 \ln(\text{Land}) + \beta_3 \ln(\text{Labor}) + \beta_4 \ln(\text{Seed}) + \beta_5 \ln(\text{Urea}) + \beta_6 \ln(\text{NPS}) + \beta_7 \ln(\text{Orgfert}) + \beta_8 \ln(\text{Chem}) + V_i + U_i \quad (19)$$

Where,

$\ln(\text{Output})$ = natural logarithm of the wheat output level of i^{th} farmer

X_i = Vector of explanatory variables, β_i = estimated parameter of Stochastic production function. ($i = 0, 1, 2 \dots 8$)

Ox is the quantity of oxen power used by the farmer in oxen-day, Land= is the size of land for wheat operation in hectares, Labor is the quantity of labor-power used by the farmer in man-days, Seed represents the quantity of seed used in quintal, Urea is the quantity of urea fertilizers used in quintal, NPS is the quantity of DAP/NPS fertilizer used in quintal, Orgfert represent the quantity of organic fertilizers used in quintal and Chem represent the amount of chemical used in liter. Whereas V_j = Random error term (i.e. random effect) U_i = Error term related with inefficiency.

The symmetric component (v_i) is assumed to be independently and identically distributed as $N(0, \sigma^2_v)$. On the other hand, (u_i) captures the technical inefficiency of the farmer and the distributional assumption of the technical inefficiency term, u_i , was estimated using the likelihood ratio test.

The variance parameters are:

$$\sigma^2 = \sigma^2_v + \sigma^2_u \quad (20)$$

$$\gamma = \frac{\lambda^2}{1 + \lambda^2} \quad (21)$$

Where λ is the ratio of the standard errors of the non-symmetric to symmetric error term (i.e. $\lambda = \sigma_u/\sigma_v$). However, there is an association between γ and λ . The reason is that λ could be any non-negative value while γ ranges from zero to one and better measures the distance between the frontier output and the observed level of output resulting from technical inefficiency.

The parameter γ measures the discrepancy between the frontier and observed levels of output and is interpreted as the total variation in output from the frontier attributable to technical inefficiency. It has a value between zero and one. The value of zero indicates that the non-negative random variable, u_i is absent from the model while the value of one shows the

absence of statistical “noise” or exogenous “shocks” from the model and hence low level of farm’s production compared to the “best” practice (the maximum output) of the other farm that is totally a result of farm-specific inefficiency. Likewise, the significance of σ^2 indicates whether the conventional average production function adequately represents the data or not.

Cobb-Douglass is self-dual production function, so to drive the dual cost frontier, the solution for the minimization problem given in Equation 19 is essential.

$$\text{Min} C = \sum \phi_n x_n \quad \text{Subject to} \quad Y_k^{i*} = A \prod_n x_n^{\beta_n} \quad (22)$$

Where $A = \exp(\beta_0)$

ϕ_n = input price

β_n = parameter estimate of the stochastic production function

Y_k^{i*} = input-oriented adjusted output level from equation 19

The following dual cost function was found by substituting the cost-minimizing input quantities into Equation 19.

$$C(Y_k^{i*}, \phi_n) = H Y_k^{i* \mu} \prod_n \phi_n^{\delta_n}$$

$$\text{Where } \delta_n = \mu \beta_n \quad \mu = (\sum_n \beta_n)^{-1} \quad \text{and} \quad H = \frac{1}{\mu} (A \prod_n \beta_n^{\beta_n})^{-\mu} \quad (23)$$

Then the efficiency scores of the given farmer can be calculated as follows:

$$TE_i = \frac{Y}{Y^*} \quad (24)$$

Where Y^* = frontier output Y = actual yield

$$EE_i = \frac{C^*}{C} \quad (25)$$

Where, C^* = minimum (efficient) cost C = actual cost

Following Farrell (1957), allocative efficiency index of the i^{th} farmer can be derived from Equations 20 and 21 as follows;

$$AE_i = EE_i / TE_i \quad (26)$$

3.4.2.2. Determinants of efficiency

After the latent variable (efficiency score) obtained from one stage stochastic frontier model; the second objective of the study was achieved by the implementation of Tobit model.

Tobit model is specified as:

$$E_j^* = \beta_0 + \sum \beta_n x_{in} + e_i \quad (27)$$

Where

Where E_j^* = latent variable representing the efficiency scores of i^{th} farmer

β = a vector of unknown parameters,

X_{nj} = a vector of explanatory variables n ($n = 1, 2, \dots, k$) for farm j and

e_i = an error term that is independently and normally distributed with mean zero and variance σ^2

Defining Y_j as the observed variables,

$$y_j = \begin{cases} 1 & \text{if } y_j^* = 1 \\ y_j^* & \text{if } 0 < y_j^* < 1 \\ 0 & \text{if } y_j^* = 0 \end{cases} \quad (28)$$

In this equation, the distribution of the dependent variable is not normally distributed because the value of efficiency score varies within the range of between 0 and 1. To determine the existing relation between explanatory variable, social factor, market factor, socioeconomic and institutional factors and the estimated score of efficiency, Tobit model was employed. There are at least two reasons to use a Tobit regression analysis (Tobin, 1958) to test the hypotheses in this thesis. First, the value of the dependent variable- efficiency scores- ranges between zero and one. The rationale behind using the Tobit model is that there may be a number of farmers for which efficiency could be “1” and the bounded nature of efficiency between “0” and “1”. That is, the distribution of efficiency is censored from above at one. Second, in a Tobit regression, the independent variable is not assumed to be normally distributed. Therefore, the inclusion of continuous and binary explanatory variables in a model is possible (Jema, 2006).

3.4.2.3. Hypothesis test

The reliability of empirical results depends on whether or not the model used satisfies certain criteria. Specifically, the models have to be correctly specified, and the assumptions or restrictions made must hold. Incorrect model and functional specifications and violations of the assumptions can lead to incorrect conclusions and recommendations (Gujarati, 2003).

The general likelihood ratio (LR) test can be used for running all the tests required under this study. LR statistic has a Chi-square distribution with degrees of freedom equal to the number of restrictions imposed (i.e. the difference between the number of parameters estimated under H_0 and H_1 respectively). The null hypothesis is rejected if the computed value of LR exceeds its critical value. A significant LR statistic implies that the null hypothesis is rejected. The generalized likelihood ratio; LR, has an asymptotic distribution which is a mixture of chi-square distribution, namely (Coelli *et al.*, 1998).

Accordingly, the LR test statistic (λ) can be calculated as:

$$LR = \lambda = -2 \ln [L(H_0) / L(H_1)] \quad (29)$$

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

Where $L(H_0)$ and $L(H_1)$ denote the values of the likelihood value for the restricted and the unrestricted frontier model respectively at 1 degree of freedom.

Test of hypothesis for the parameter of the Frontier model was conducted by using Generalized Likelihood ratio statistics: the tested hypotheses were:

1. To select the preferred functional form for the collected data set
2. To test the existence of technical inefficiency component
3. For the variables that explain the variation in efficiency among farmers

Hypothesis 1: The first hypothesis is concerned with the selection of an appropriate functional form that describes the data set adequately.

The null hypothesis (H_0): The Cob-Douglas production function describes the data set.

The null hypothesis (H_1): Trans-log production function is an adequate representation of the data set.

Hypothesis 2: The second hypothesis is concerned with technical efficiency

The null hypothesis (H_0): Wheat producers in Robe district are technically efficient and no production loss is attached to the Technical efficiency of wheat producers.

The alternative hypothesis (H_1): Wheat producers in Robe district are technically not efficient and there was wheat production loss.

Hypothesis 3: The third hypothesis is the effect of the inefficiency variables on model

The null hypothesis (H_0): The variables included under the inefficiency effects model are not jointly affecting the efficiency of the farmers in the study area.

The alternative hypothesis (H_1): The variables included under the efficiency effects model are affecting the efficiency of the farmers in the study area.

3.5. Variables Definition and Working Hypothesis

3.5.1. Production function variables

Output: It is the dependent variable in the estimation of production functions which is measured in quintals. The data was collecting by using different local measurements of output then it was converted into the standard measurement unit which is Quintal. The output of wheat produced by sample households in quintals in the production season of year 2018/19 was used in the analysis.

Inputs: Defined as the total inputs used in the production of wheat namely: oxen, land, labor, seed, fertilizers (organic and inorganic) and chemicals used during the 2018/19 production year.

Ox power: The amount of draught power used for different farming activities for wheat production is measured in oxen day. It is a continuous variable which represents the number of oxen-days measured in pair of oxen-days per hectare of land used for wheat-producing by a single farmer. It was hypothesized as; farmers who used the number of pair of oxen-days were more productive in wheat production than those who used fewer amounts of pair of oxen days. The number of oxen holding has a significant positive effect on all three types of efficiency (Alelign, 2017).

Land: This refers to the area of the plot of land allotted for wheat production. The unit of measurement for the area is also different in different parts of the country; hence the data was changed to hectare for smoothness. Accordingly, a hectare of a plot of land used for wheat production was used in the analysis. The land has a positive and significant effect on technical efficiency (Kusse *et al.*, 2018).

Labor: Amount of Labor (family and hired labor) per household (expressed in man-days) used in Wheat production and converted to a homogeneous variable using the standard conversion. It was hypothesized that it has a positive effect on wheat output and efficiency. Labor has a

positive and significant effect on output and technical efficiency (Sihlongonyane *et al.*, 2014, Tarekegn, 2017; Ermias, 2013).

Quantity of seed: It is a continuous variable which refers total quantity of wheat seed used by the i^{th} farmer per hectare of land measured in Quintal. It was hypothesized as; increasing the amount of seed up to the required threshold has a positive effect on wheat output. The seed has a positive effect on the output (Ermias, 2013).

Quantity of inorganic fertilizer used: It is a continuous variable measured in Quintal which refers to the total amount of fertilizer (NPS/DAP and UREA) used by i^{th} farmer per hectare of the wheat production. It was hypothesized with a positive effect on the wheat output. In this study, it was not possible to aggregate chemical fertilizers (NPS/DAP and Urea) into one variable as the Quantity used by farmer and Price variations were high. The quantity of these inorganic fertilizer used by the farmer was varies based on the water content of wheat plot land and the available rain of the production season. If wheat plot land has high water content the farmers apply more of Urea than DAP and vice versa. As well as the purchase price of both fertilizers has great difference. If price were used to aggregate fertilizers, the resulting efficiency estimates would have been biased. This is because the resulting difference in economic efficiency would not be only due to input variations but also price variations. Due to this fact, Urea and DAP were not aggregated into one variable in the analysis. The study by Wollie *et al.* (2018) found that this variable has a positive effect on barley production output. The study By Sihlongonyane *et al.* (2014) found that the amount of fertilizer used had significant and have a positive effect on maize yield. Both DAP and Urea has a positive effect on technical efficiency and significant at 1% significance level (Kusse *et al.*, 2018).

Organic fertilizer: It is continuous variable is measured by Quintal; the amount of manure that the farmers used in their land preparation for sowing wheat. This organic fertilizer comes from animal excreta and the possession of livestock by a household usually implies its availability. It was hypothesized to have a positive effect on Economic efficiency. The use of organic fertilizer minimizes the amount of inorganic applied by the farmers which in turn save the cost of fertilizer

purchases. The result by Alelign (2017) indicates that the level of farm households' participation in fertilizer purchase is negatively and significantly affects the quantity of manure used.

Chemicals: It is continuous variable measured by litter, the amount of chemicals such as herbicides, insecticides, and pesticides applied by the sample households for protection of weed, insects, and pests in wheat production, respectively. It was hypothesized as it has a significant positive effect on the wheat output. The result obtained by Kifle (2014) indicates that the amount of chemicals affect the maize output positively and significant at 1% significance level. A chemical such as a pesticide and herbicides has a positive effect on output and technical efficiency and significant at 1% significance level (Kusse *et al.*, 2018).

3.5.2. Cost variables

Input variables: These refer to the explanatory variables which were used in the estimation of frontier/minimum cost of production. These variables were assumed as positively related to the total variable cost of wheat production.

Price of an ox: This was estimated as the amount of payment that renters paid for the oxen. The average price obtained from this survey was 30 ETB per oxen-day was used.

Price of land: It is the annual cost of land (average rental value of land and payments for tax) which was estimated as 5000 ETB/ha was used as a price of land.

Price of labor: For hired labor, the wage paid to the workers was recorded and for family labor (unpaid workers) it was estimated as the wage paid in the locality for the same quality labor. The average wage rate for hired labour in the locality which was 70 ETB/MD was used.

Price of seed: This represents the current Average market value of seed which was 1450 ETB/qt was used.

Price of inorganic fertilizer: This refers to the current average market value of fertilizer (NPS and urea) which was 1500 ETB/qt and 1350 ETB/qt respectively was used.

Fv

Price of organic fertilizer: Actually organic fertilizer has no real market value but it was estimated based on how much farmers value it. According to farmers estimation; its average market value was 150 ETB per quintal.

Price of chemicals: This refers to the current average market value of chemical which was 450 ETB/Lt was used.

3.5.3. Efficiency variables

Technical, allocative and economic efficiencies: Efficiency scores of wheat production obtained from stochastic frontier Production Function were the dependent variables that have the value of between zero and one. After the deep literature reviews; the following variables were hypothesized to affect the three efficiencies (TE, AE, and EE) of wheat of production.

Farm experience: It is continues variable measured by number of year farmers' use on wheat production. Can be used as a proxy variable for an age of farmers in wheat production. Through continues production period farmer adopt the technique of production and climatic behavior this leads farmer to be more productive. The older household heads are more experienced and more technically, allocatively and economical efficient. It was hypothesized as it has a significant positive effect on the Technical, allocative and economic efficiencies. Experience has a significant positive effect on technical efficiency and also has a significant negative effect on allocative efficiency (Gosa *et al.*, 2016).

Education: It is a continuous variable measured in grade level completed. It can be used as a proxy variable for the farmers' ability of the decision-making unit. The educated farmers were able to make decision on production system and also Farmers with more years of formal education completed tend to be more efficient, because of enhanced ability to acquire technical knowledge, which makes them closer to the frontier. It was hypothesized as positive effect on Technical, allocative and economic efficiency. The study by Wollie *et al.* (2018) found that Education has a positive effect on the technical efficiency and significant at 10% significance level. It has also a positive effect on allocative and economic efficiency and significant at 1% significance level.

Family size: It is continues variable measured by the total number of family members in the household (in adult equivalent). High numbers of family member were reducing the cost that farmers incur to hire labor for additional work and own worker is more interested to work his own work and effective than hired labor. As well as households with many members have better advantage of being able to use labor resources at the right time, particularly during peak

cultivation periods. So it was hypothesized with a significant positive effect on the three types (TE, AE and EE) efficiency. Family size has a significant positive effect on the level of technical efficiency (Fategn, 2017).

Land holding: It is continues variable which shows the total land coverage operated by the farmer, measured by hectares. Farmers with larger area of cultivated land have the capacity to use compatible technologies that could increase the efficiency of the farmer, enjoy economies of scale. It was hypothesized with a positive effect on the three levels of TE, AE and EE efficiencies. According to Gosa and Jema (2016) this variable has a significant positive effect on both technical efficiency and economic efficiencies.

Livestock: It is continues variable measured by the number of livestock holding by the farmers in tropical livestock unit (TLU). Livestock could support crop production in many ways; it can be source of cash, draft power and manure that will be used to maintain soil fertility. It was hypothesized that the number of livestock owned determines technical, allocative and economic efficiency levels of farmers positively. The livestock ownership variable has a positive effect on both Allocative efficiency and Economic efficiency and significant at 5% significance level (Wollie *et al.*, 2018; Bati *et al.*, 2017). Livestock holding has a positive effect on allocative efficiency of cumin producers (Tarekegn, 2017).

Extension contact: This variable is measured by the number of visits made by the extension agents to sample household. It is expected households that have frequent contact with extension workers was have better accesses to information and new technology that enhance their productivity. The higher the linkage between farmers and development agents, the more the information flows and the technological (knowledge) transfer from the latter to the former. It was hypothesized with a positive on TE, AE and EE. The results by (Musa *et al.*, 2013) indicate that this variable has a significant positive effect on technical efficiency. Technical, allocative and economic efficiency are positively and significantly influenced by the frequency of extension contact (Sisay *et al.*, 2015).

The average distance from plots: This variable is continuous; which is measured by kilometer in which the wheat plot land far from home. The furthest the distance from the farmer field, the less the supervision then less efficiency of farmers increases as the distance between farm and homestead increases. It was hypothesized as; the high distance between home and plot has a negative effect on technical, allocative and economic efficiencies. A high distance of plot land for production from home has a negative effect and significant at 1% significance level (Alelign, 2017; Kusse *et al.*, 2018; Getachaw, 2018).

Distance from the market: It is a continuous variable measured by kilometer in which the market place far from home house. Home located far from the market incurs more costs to transport farm inputs from the market, compared to the one closer to the market. This in turn, hinders the optimal application of farm inputs and leads to less efficiency. It was hypothesized with a negative effect on technical, allocative and economic efficiencies. Distance to the market has a significant and negative effect on Technical efficiency (Getachaw, 2018 and Alelign, 2017).

Credit: It is continuous variable which is measured by the amount of credit the farmer borrowed in ETB. Credit availability shifts the cash constraint outwards and enables farmers to make timely purchases of those required inputs that they cannot provide from their own sources and utilized an important source of financing the agricultural activities of smallholder farmers. It was hypothesized to have a positive relationship with the technical, allocative and economic efficiencies. Credit significantly and positively determines the level of technical efficiency in a farming system (Getahun, 2014; Musa *et al.*, 2015).

Nonfarm income: This variable is continuous; which is measured by ETB that shows the amount of income that farmers obtain when they are engaged in non-farm activities. The availability of non-farm income shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs which they cannot provide from on farm income and the income obtained could be used for the purchase of agricultural inputs and augments financing of household expenditures. It was hypothesized to determine technical, allocative and economic efficiencies positively. Those farmers who participated in nonfarm activities obtain additional income. Participation of the household in non-farm income activities has a positive effect and significant on both allocative and economic inefficiency (Getachew, 2018).

Distance from farmer training center (FTC): Farmers get farm-related information through training. The far distance of home from the farmer training center hinders this information; due to this, it affects wheat production and productivity. Based on this assumption; It was hypothesized with a negative effect on the Technical, allocative and economic efficiencies. Distance to FTC negatively related with the technical efficiency of the crop (Alelign, 2017).

Time of sowing: Sowing time is a dummy variable where (1) indicates early sowing and (0) otherwise. Early sowing start from mid-end of August and late sowing is at the end of September. Hypothesized as with the favorability of weather condition early sowing has a positive effect on all three types of efficiencies (TE, AE and EE). Time of sowing has a positive effect and significant on both Economic efficiency and allocative efficiency (Fategn, 2017). Time of sowing has a significant and positive effect on the output of paddy (Karla *et al.*, 2015).

Plot ownership: It is a dummy variable whether the wheat producer farmer owns the wheat plot land or rents from the others. Value (1) assigned for owners and (0) otherwise. Households are expected to give priority, especially during peak periods of farming like weeding, to their own plot. It was hypothesized as the farmer who owns the land is more technically, allocatively and economically efficient than the farmer who owns the land through sharecropping and renting. The ownership measured in terms of a dummy is found to determine the efficiency level of farmers in producing wheat positively and significantly at 1% of significance (Asefa, 2016).

Soil fertility: It is dummy variable whether the wheat plot land is fertile (1) and (0) otherwise. The more the land is fertile; the better is the gain, since fertile land saves the cost of purchase fertilizers. It was hypothesized as farmers with fertile plot is more technically, allocatively and economically efficient than farmers with infertile plot. Fertile plots of wheat are significantly more economically efficient than infertile one (Solomon, 2014).

Sex: It is dummy variables whether participants in wheat production activity (ploughing, harvesting and etc) is male (1) or female (0). Male farmers are more likely to attend meetings, frequent follow-ups and supervisions of their farms than females. The assumption is that, firstly, women in the area do not carry on plowing by themselves. The practice is either they rent out their land for sharecropper or look for someone who does the plowing operation, which affect

timely operation. It was hypothesized as male participants were more Technically, allocatively and economically efficient than a female participant. It has a significant negative effect (in favour of male) on allocative efficiency (Sihlongonyane *et al.*, 2014).

Method of sowing: This is a dummy variable whether the farmers sow wheat seed in broad Band maker (BBM) (0), or they sow in Row (1). Row planter farmers is more productive and efficient, since the row planting technology is more systematic technique and uses crops from water and more productive and efficient than Broad band maker. It was hypothesized as farmers who sow wheat by row was more technically, allocatively and economically efficient as compared to the farmer who sows by Broad band maker. Row planting has a significant and positive effect on both Economic and allocative efficiency (Fategn, 2017).

Membership to a cooperative: It is the case in which farmers are members of cooperatives. It is a dummy variable whether farmers are a member of cooperative (1) or (0) otherwise. Cooperative member farmers are expected to be more efficient than non members since cooperative guide them to share information to each others. It was hypothesized with significant and positive effect (In favor of members) on level of TE, AE and EE. All three types of efficiency are significantly and positively affected by cooperative membership (Sisay *et al.*, 2016).

Training: It is a dummy variable whether the farmer got training specifically on wheat production (1) or (0) otherwise. Get training guide farmers to be more technique and efficient in ways of input application and production system. It was hypothesized as training had positive effect on Technical, allocative and economic efficiency. According to the study by Getahun, 2014 and (Beyan *et al.*, 2013) training was positively affect the level of farmers technical efficiency.

Crop rotation: This is a dummy variable whether the farmer adopts crop rotation (1) or not (0). Crop rotation helps farmers to increase output by recycling and restoring nutrients required for wheat production. It was hypothesized as the farmer who adopts crop rotation is more technically, allocatively and economically efficient than the farmer who not adopts crop rotation. Crop

rotation has significant positive effect on the level of farmers technical efficiency (Mustefa, 2014).

Combiner: This is a dummy variable whether the farmer use or not use the combiner (1) or not (0). Technology had significant productive effect on production. Using harvester machine than human labor force is more appropriate to take production output on peak harvesting time that save storage, loading and unloading cost of farmers. It was hypothesized as the farmer who uses combiner is more technically, allocatively and economically efficient than the farmer who not uses combiner. The study by Kusse *et al* (2018) found that the harvester machine had significant positive effect on the level of economic efficiency.

4. RESULTS AND DISCUSSION

This chapter presents and discussed the results in two sections; descriptive and econometrics section. The descriptive statistics presents; demographic and socioeconomic factors of farmers, institutional, the farm characteristics and land distribution in the study area. While the econometric section deals with econometric results from the stochastic frontier function and Tobit model.

4.1. Demographic and Socioeconomic factors of the Sample Households

4.1.1. Demographic Factors of the Sample Households

Age: The average age of the sample household heads was 39.75 years varying between 20 and 66 years. This implies that the mean age of the sampled households was within the range of economically active age group (29-60). The average farming experience of the sampled farmers in wheat production was 19.7 years with a minimum of 5 years and a maximum of 43 years.

Family Size: The mean family size in adult equivalent that live in one house for the sample households was about 7.20 persons ranging between 2.5 and 15.32 persons with the standard deviation of 3.53 which is a bit higher than the country level average family sizes which were 5.1 persons per household.

Table: 2. Age, family size and farming experience

Variables	Mean	Standard Deviation	Minimum	Maximum
Age	39.75	9.32	20	66
Farm experience	19.67	8.32	5	43
Family size	7.20	3.53	2.5	15.32

Source: own computation, 2019

Sex: The analysis results indicate that about 91.13% of the sampled farmers were male headed and the remaining 8.87% were female headed.

Marital status: Among the sampled farmers considered, 94.1% were married. While, 3.94% and 1.96% were divorced and widowed respectively. Considering the religion of sample households about 56.7%, 33% and 10.7% were Muslim, Orthodox and Protestant respectively.

Table: 3. Sex, marital status and religion of sample households

Variables	Category	Percent
Sex	Female	8.87
	Male	91.13
Marital Status	Married	94.10
	Divorced	3.94
	Widowed	1.96
Religion	Muslim	56.70
	Orthodox	33.00
	Protestant	10.30

Source: own computation, 2019

4.1.2. Socioeconomic factors of the Sample Households

Education: The average educational level of sampled household head in the study area was 3.6yrs with the minimum of zero grade or illiterate and maximum of grade 10 formal educational levels. The Majority of the household heads were literate.

Non-farm income: Farmers in the study area are engaged in various non-farm activities in parallel with the main farming activities during the farming season. Some of these activities are; petty trade, woodwork, handicraft, and selling of local drinks. About 48.28% of the sample

farmers reported that they participate at least in one of the non-farm activities listed above and about 51.72% of sample households were not participating in any of these activities. The mean income obtained from the above listed non-farm activities by sampled farmer's was 3879.82 ETB with standard deviation of 6411.2 and varies from minimum of zero ETB to maximum of 31000 ETB per year. The result of two-sample t-test on the income from non-farm activities indicate that there is a significant difference in mean of efficiency scores at 1% probability level between the two categories.

Oxen: On average, the sampled farmers have three (3) oxen with the minimum and maximum of zero and ten respectively. Some of the sampled household heads were the owner of two oxen (about 41.87%). 29.56% and 16.26% of sampled farmers were the owners of three and four oxen respectively. Only 0.49% of them have no ox and about 0.99% of them have an ox. Around 10.84% of the sampled farmers have more than two pair of oxen.

Livestock ownership (TLU): Sampled farmers on average; owned livestock of 11.27 TLU ranging from 3.2 to 26.84 TLU.

Table: 4. Education level, Non-farm income and Livestock of sample households

Variables	Mean	Standard Deviation	Minimum	Maximum
Education level	3.60	2.41	0.00	10.00
Non-farm income	3879.82	6411.20	0.00	31000.00
Ox	3.01	1.31	10.00	0.00
TLU	11.27	4.07	26.84	3.20

Source: own computation, 2019

4.2. Institutional Characteristics of Sample Households

Credit services: There exist both formal and informal lending institutions that provide credit to farmers. Omo micro-finance, Vision fund micro-finance and local cooperative were the formal sources of credit in the study area; whereas local lenders like friends, relatives, traders, *idir* etc: are informal sources from which farmers could get credit. As far as access to credit is concerned, 36.45 percent of the farmers reported that they are credit users; of which 63.5% obtained credit from formal institutions and 36.5% obtained credit from non-formal institutions. More than half

(63.55%) of sampled households were not users of credit, of which 76.74% refused the use of credit due to fear of high-interest rate, 14.73%, and 8.53% refused due to religious and improper repayment period respectively. households use the credit to purchase inputs such as fertilizer, seed, chemicals (herbicides and fungicides) and other basic needs. On average the amount of credit used by farmers were 2810.84 ETB that varies from the minimum of zero ETB to 15000 ETB.

Extension service: About 99% of the sampled households reported that they received extension services though the frequency of contact differs. The average frequency of extension contact was 15.3 days and varies from 3 days to a maximum of 53 times per wheat production season. Some of the respondents indicate that they had extension contact on monthly basis which was about 44.28% of sampled household heads. The remaining 38.81% and 16.92% of sampled household heads get their contact on biweekly and weekly respectively. The other case in extension contact was a place of contact between the extension agent and farmers. About 52% of respondents indicated that they had extension contact at the office of the development agents and 37.81% and 9.95% had extension contact at the farm and at meeting place respectively.

Distance from market and FTC: the mean distance between farmers home and market was 19.01Km that ranges from minimum of 2Km the nearest to the maximum of 43 Km which is the longest distance among the sampled farmers. As well as farmers home far from farmers training center on average 8.04Km ranges from 1Km to 21 Km.

Table 5. Amount of Credit used by farmers, Frequency of extension contact, Distance from market and Distance from farmers training center.

Variable	Mean	Std. Dev	Minimum	Maximum	
Amount of Credit used	2810.84	4019.21	0.00	15000.00	
Extension contact	15.30	11.50	3.00	53.00	
Distance from Market	19.01	10.84	2.00	43.00	
Distance from FTC	8.04	4.58	1.00	21.00	
Contact Schedule for Frequency of Extension contact					
	Number	Percent	Place	Number	Percent
Weekly	34	16.92	At DA office	105	52.24
Biweekly	78	38.81	At farm	76	37.81
Monthly	89	44.28	On meeting	20	9.95

Source: own computation, 2019

Training: From the sampled household heads only 56.65% got training, specifically on wheat production. The remaining 43.35% did not receive training on wheat production. Two-sample t-test with equal variance was used on the training; to compare the difference in the efficiency scores between two groups (trained and non-trained). There was a significant difference between the two categories. The mean difference between the two categories was found to be statistically significant at 1% probability level for all of the three types of efficiency scores.

Cooperative membership: The sampled respondents were indicating that around 40.39% was a member of local farmer's cooperative organizations and more than half 59.61% were not cooperative membership. Two-sample t-test with equal variance was used on the cooperative membership to compare the difference in the efficiency scores between two groups (members and non-members). There was a significant difference between two groups. The mean difference between the two categories was found to be statistically significant at 1% probability level for all of the three efficiency scores.

Table 6. Efficiency scores Compared between two groups of Training (Trained vs. non Trained) and Cooperative (Member vs. Nonmembers) of sample households

Categories	Num ber	Percent	TE	AE	EE
			Mean(Std. Err)	Mean(Std. Err)	Mean(Std. Err)
Non-trained	88	43.35	0.82 (0.005)	0.78 (0.01)	0.64 (0.01)
Trained	115	56.65	0.89 (0.002)	0.82 (0.01)	0.73 (0.01)
Combined	203		0.857 (0.003)	0.80 (0.01)	0.69 (0.01)
Difference			-0.069*** (0.01)	-0.05*** (0.02)	-0.09*** (0.02)
t-value			-13.67	-2.78	-6.16
Non-member	121	59.61	0.83 (0.004)	0.78 (0.01)	0.65 (0.01)
Member	82	40.39	0.90 (0.001)	0.84 (0.01)	0.75 (0.01)
Combined	203		0.857 (0.003)	0.80 (0.01)	0.69 (0.01)
Difference			-0.07*** (0.01)	-0.06*** (0.02)	-0.10*** (0.02)

t-value	-12.62	-3.24	-6.55
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Note *** Significant at 1% level of significance

Source: own computation, 2019

4.3. Farm Characteristics of Sample House hold head

Method and time of sowing: The sampled households used two main types of sowing methods for wheat. The first was the row planting method, which was only practiced by 21.18%. The second was Broad Band Maker (BBM). This method was adopted by 78.82% of the sampled households. From the total sampled households 87.68% were sowing on the first category of sowing period (early) and the remaining 12.32% were sowing on the second category (late) sowing period. Two-sample t-test was applied on the method of sowing to compare the difference in the efficiency scores between two groups (BBM and Row-planter). There was a significant difference between two groups. The mean difference between the two categories was found to be statistically significant at 1% probability level for technical and economic efficiency scores and at 10% for allocative efficiency.

Fertility status of the soil: The result of the survey showed that 66.01% of the respondents classified their wheat plot as “fertile” and the remaining respondents (33.99%) classified it as “infertile”. Their perception to categorize their wheat plot as fertile or infertile was based on their comparative quantity of wheat output per hectare. Sample farmers were considered their farm as fertile if it gives better yield than their neighbors and infertile otherwise. The result of two-sample t-test on the fertility status indicate that there is a significant difference in mean of efficiency scores at 1% probability level between fertile and non-fertile wheat plot of sample households.

Crop rotation: Crop rotation reduces weed, crop disease, and insects that cause losses of outputs and helps to reduce the amount of chemical fertilizer applied. As shown in Table10, 70.94% of the sampled households practice crop rotation. The remaining 29.06% did not practice crop rotation. Sample t-test was applied on the crop rotation practices to compare the difference in the efficiency scores between two groups (practice and non-practice). There was a significant

difference between two groups. The mean difference between the two categories was found to be statistically significant at 1% probability level for the three efficiency scores.

Table 7. Method of sowing, Fertility status and Crop rotation

				TE	AE	EE
				Mean(Std. Err)	Mean(Std. Err)	Mean(Std. Err)
Method of sowing	BBM	160	78.82	0.87 (0.002)	0.81 (0.01)	0.71 (0.01)
	Row	43	21.18	0.80 (0.01)	0.79 (0.02)	0.62 (0.02)
	Combined	203		0.857 (0.00)	0.02 (0.01)	0.69 (0.01)
	Difference			0.077*** (0.01)	-0.13* (0.02)	0.09*** (0.02)
	t-value			11.84	1.48	4.48
Plot Fertility status	Non-fertile	69	33.99	0.81 (0.01)	0.76 (0.02)	0.61 (0.01)
	Fertile	134	66.01	0.88 (0.00)	0.83 (0.01)	0.73 (0.01)
	Combined	203		0.857 (0.00)	0.857 (0.00)	0.69 (0.01)
	Difference			-0.08*** (0.01)	-0.07*** (0.02)	-0.12*** (0.02)
	t-value			-16.30	-3.88	-7.7371
Crop Rotation	Non-practice	59	29.06	0.80 (0.01)	0.76 (0.02)	0.61 (0.02)
	Practice	144	70.94	0.88 (0.00)	0.81 (0.01)	0.72 (0.01)
	Combined	203		0.857 (0.00)	0.80 (0.01)	0.69 (0.01)
	Difference			0.08*** (0.01)	-0.055*** (0.02)	-0.11*** (0.02)
	t-value			-16.21	-2.99	-6.70

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

Source: own computation, 2019

4.4. Role of Machine in wheat production

Tractor and combiner: The use of cost-effective technology is one of the factors that increase the performance of output by directly raising the level of production. The currently available wheat production technology in the study area was tractor and combiner. Both technology

hindered by various linked constraints on the application of land preparation. Due to these constraints, a few farmers practiced these technologies. Among the sampled farmers only 5.9% and 21.67% of them were the users of tractor and combiner and the remaining 94.1% and 78.33% were non-user of tractor and combiner respectively. The main constraints raised by sampled farmers in the application of these technologies were; 23% of sampled farmer refuse the use of tractor due to fear of the high cost of operation and 6.8% of them leave the application of machine due to unavailability of the machine. Those who used the application of tractor for only other than the preparation of land for wheat (about 70.2% of non-users) refuse the expansion of the use; as the case of the two main indicated problems. On the other hand, the main constraints raised by sampled farmers on the use of combiner were; the machine was not saved crop residuals that used as feed for animals (40.2% of sampled farmers), unavailability on time (30.2% of sampled farmers) and high cost of operation (29.6% of sampled farmers) (table 8).

Table: 8. Role of a machine in the preparation of land for wheat

Machine	Users (%)	Non-users (%)
Tractor	5.90	94.10
Combiner	21.67	78.33

Source: own computation, 2019

4.5. Land Holding and Distribution by Sampled Households

The average own landholding of the sample households was 2.79 ha while on average 2.75 and 0.31 ha of land were cultivated and home land, respectively. The average number of total plots operated by the sampled household heads during the survey period was 3.7 in number with a minimum of 2 plots and a maximum of 7 plots. The frequency of ploughing indicates an intensity of land preparation that helps for appropriate germination of the seed. On average the respondents plough their land 3.7 times from the minimum of 2 times to a maximum of 6 times. As it is presented in Table 16, the average distance of wheat plot from residence of farmers home was about 4Km; ranging from the minimum of 0.75Km to of maximum 8Km.

Table: 9. Land distribution of sampled household heads

Variable	Mean	Std. Dev.	Minimum	Maximum
Total cultivated farm land	2.75	1.11	1.5	5.75
Total land	2.79	1.00	1.18	5.49
Number of plots operated	3.69	1.33	2	7
Grazing land	0.31	0.14	0.05	1
Home land	0.02	0.02	0.01	0.05
Frequency of plowing	3.67	0.87	2	6
Average plot distance from home	4.10	2.09	0.75	8

Source: own computation, 2019

In the study area, some of the farmers practice share-cropping and renting. From the total sampled households, 78.8% produced a wheat crop on their own land and about 8.4% and 5.4% participated in shared-in and share-out cropping system but, 7.4% of them participated in rent-in land while about 5.9% of them involved in rent-out their land.

Table 10. Participation of sampled households in sharing and renting of land for wheat

Activity	No. of Participants	Percent (%)	No. of Non-Participants	Percent (%)	Mean of Land (ha)
Shared-in	17	8.4	186	91.6	0.63
Share-out	11	5.4	192	94.6	1.2
Rent-in	15	7.4	188	92.6	0.14
Rent-out	12	5.9	191	94.1	

Source: own computation, 2019

4.6. The Main Crops Grown and Land Allocated by Sample Households

The major crops grown in the study area includes wheat, maize, *teff*, barley, bean, oilseed, and sorghum. All of the sampled households in the study area were produce wheat, maize, *teff*, and barley. Robe district is representative of the *dega* and *weina- dega* agro-climatic condition and has two harvesting seasons. The first is during the main rainy season *Meher* (May to February), during this season predominant crops are grown by households; such as wheat, *teff*, maize, beans, oilseed, and sorghum. The second is during small rain season *Belg* (April to August) during this season barley, pea and small amount of wheat are grown.

On a mean, sample households allocated 1.04 ha (28.18%) of the total cultivated land for wheat production. Next, to wheat, maize and *teff* were crops that took the largest proportion of the household's total cultivated land covering 0.52 ha, equally. The sample household heads allocated 0.47, 0.42, 0.37 and 0.35 ha of the total cultivated land for barley, bean, sorghum, and oilseed respectively. The land allocated for *Belg* season crops (Barley and others) again used for *Meher* season crops (Wheat, *teff*, and bean). The farmers in the study area use their cultivated land simultaneous for crops grown in the same production season and substitutes for crops produced in different production season such that land plot used for Barley production in *Belg* season may again be used for other crops (wheat, *teff*) in another production season.

Table 11. Average crops yield of major crops grown and area allotted by sample households heads

Crop type	Area allotted			Yield(Qt/ha)	
	Number	Mean	Percent	Mean	Percent
Wheat	203	1.04	28.18	24.86	15.51
Maize	203	0.52	14.10	28.17	17.57
<i>Teff</i>	203	0.52	14.10	22.29	13.90
Barley	203	0.47	12.74	31.74	19.80
Bean	71	0.42	11.38	11.62	7.25
Oilseed	64	0.35	9.50	18.49	11.53
Sorghum	79	0.37	10.02	23.15	14.44

Source: own computation, 2019

The survey result also demonstrates that the average yield of major crops in quintals per hectare. Given the difference in productivity (when the effect of all inputs on yield simultaneously considered.) sampled household heads on average got 24.86 quintal per hectare of wheat which was 15.51% of total yield. The obtained average wheat yield in the study area was less than the national level of wheat yield (27.36qt/ha). This average wheat yield was the third as compared to the average yield from others produced main crops. It is preceded by the mean yield of barley and maize which was 31.74Qt/ha and 28.17Qt/ha respectively. The yield of wheat was followed by the yield of sorghum, *teff*, oilseed, and bean with an average yield of 23.15 Qt/ha, 22.29 Qt/ha, 18.49 Qt/ha and 11.62 Qt/ha respectively (Table 13).

4.7. Wheat Production Problems

Climate variability was a serious problem that farmers were facing in the study area followed by crop disease and weed infestation. About 43.8% of respondents reported that they were facing a Climate variability problem whereas 22.2% believes crop disease was the problem that they were facing.

Table 12. Wheat Production constraints

Problem	Number	Percent
Pests	15	7.4
Crop disease	45	22.2
Weed infestation	39	19.2
Lack of improved seed	15	7.4
Climate variability	89	43.8

Source: own computation, 2019

4.8. Summary Statistics of Production and Cost Function Variables

The production function for this study was estimated by using the wheat output as the dependent variable and eight input variables (Oxen power, land, labor, seed, urea, NPS, organic fertilizer and chemicals) as an independent. The average wheat output produced in the study area was 23.4 qt that ranged from 4.5 qt to 115 qt with a standard deviation of 18.94 among the sample farmers in 2018/19 production season and the mean of potential wheat output was 26.79qt with standard deviation of 21.02. The average oxen power, land, labor, seed, urea, NPS, organic fertilizer and chemicals used by sample household were 11.8 Ox/Day, 1.04ha, 42.12 man-days, 1.52qt, 1.02qt, 1.12qt, 0.31qt, and 2.74 liters respectively. Paired sample t-test was used on the actual and frontier output to compare the difference in the amount of yield between two scenarios. There was a significant difference between frontier output and observed output. The mean difference of the observed and the frontier output was found to be statistically significant at 1% probability level.

Table 13. Summary statics of variables included in the Cobb-Douglass production function

Variables	Measurement	Mean	Std. Dev	Min	Max
Actual wheat output	Quintal	23.40	18.94	4.5	115.00
Frontier wheat output	Quintal	26.79	21.02	5.74	166.52
Oxen power	Ox-Day	11.8	5.22	8.17	41.57
Land	Hectare	1.04	0.74	0.25	4.00
Labor	Man-Days	42.12	15.33	16	124
Seed	Quintal	1.52	1.04	0.25	7.50
Urea	Quintal	1.02	0.56	0.25	4.00
NPS	Quintal	1.12	0.98	0.5	7.50
Organic fertilizer	Quintal	0.31	0.47	0.01	2.00
Chemicals	Liter	2.74	0.97	1	6.00
Paired sample t-test				t = 20.98	

Source: own computation, 2019

On average, farmers had required to invest 16823 amounts of ETB to produce 23.4 quintals of wheat output. From their total income, the wheat-producing farmers had spent a higher amount of money for land which was 5249.4 ETB (31.2%) on average. Followed by labor and seed cost of 2947.6 ETB (17.52%) and 2198.5 ETB (13.07%) respectively. While, they spent a medium proportion of their expenditure for NPS, oxen cost, urea cost and chemical cost of 1730.20 ETB (10.3%), 1353.5 ETB (8.1%), 1338.03 ETB (7.95%) and 1232.7 ETB (7.3%) respectively. while they spent the least proportion of their expenditure which was 41.9ETB (0.25%) for the application of organic fertilizer (Table 21).

Table 14. Summary statistics of variables used to estimate the cost function

Variable	Unit	Mean	Percentage
Oxen costs	ETB	1353.5	8.05
Land costs	ETB	5249.4	31.20
Labor costs	ETB	2947.6	17.52
Seed costs	ETB	2198.5	13.07
Urea costs	ETB	1338.03	7.95
NPS costs	ETB	1730.2	10.28
Organic fertilizer costs	ETB	41.9	0.25
Chemical costs	ETB	1232.7	7.33
Other costs	ETB	932.93	5.55
Total cultivation costs	ETB	16823	100.00

Source: Own computation, 2019

4.9. Econometric Results

In this section, econometrics model results such as hypothesis testing, estimated result from production and cost function, efficiency scores and factor causing variations in inefficiency between sampled households are presented and discussed. The stochastic production frontier was applied using the maximum likelihood estimation procedure. The dependent variable of the estimated model was wheat output (qt) produced during 2018/19 production year in production season of May 2018 to February 2019) and the input variables used in the analysis were oxen (oxen-days), land allotted for wheat (ha), labor (man-days), seed (qt), urea (qt), NPS (qt), organic fertilizer (qt) and chemicals (lit). To include those farmers who did not apply organic fertilizer in the estimation of the frontier a very small value that approaches to zero was assigned for non-users of organic fertilizer.

4.9.1. Hypothesis testing

Before starting on discussions of the output of the model, different essential hypothesis testing was conducted to identify the appropriate functional form, for effect of inefficiency variables and for the existence of technical inefficiency component of the composed error terms of the stochastic production function. The following specification tests were performed using generalized likelihood ratio tests: $LR^2 = -2[L(H_0) - L(H_1)]$, where $L(H_1)$ and $L(H_0)$ were the values of the log-likelihood functions under the alternative and null hypothesis, respectively (Greene, 1980). The first hypothesis testing was choosing the appropriate functional form for the data from the Cobb-Douglass and Trans-log production frontier. In order to select the most appropriate functional form which adequately represents the data, both Cobb-Douglass and Trans-log frontiers were estimated using MLE method.

Table 15: Generalized likelihood ratio tests of hypothesis for the parameters of the SPF

Null Hypothesizes	LH_0	LH_1	Calculated Value	Critical Value	Decision
$H_0: \beta_{ij}=0$	-119.32	-101.07	36.50	40.11	Fail to reject
$H_0: \mu = \text{exponentially}$	-119.32	-119.03	0.585	3.84	Fail to reject
$H_0: \gamma=0$			0.846		Reject
$H_0: \delta_1=\delta_2=\dots=\delta_{20}=0$	-119.32374	-42.33	154.0	37.57	Reject

Source: own computation, 2019

The first hypothesis was that selecting the appropriate functional form which fits the data set by using the likelihood ratio test. The most common functional forms reviewed in most previous researches were Cobb-Douglass and Trans-log. The likelihood test statistic is calculated in the following way as; $LR = -2*[lr(\text{Cobb-Douglas}) - lr(\text{Trans-Log})]$.

By using this formula $LR = -2[-119.32374 + 101.07] = 36.50$. The statistic is distributed chi-squared with degrees of freedom equal to the number of variables added to the alternative hypothesis; in this case, the degrees of freedom were 27. The calculated value (36.5) is lower than the upper 5% critical value of the Chi-square with its respective 27 degrees of freedom (that is 40.11). Therefore, the null hypothesis was not rejected that says all coefficients of the square and the cross product or interaction terms in the trans-log specification are equal to zero. This implies that the Cobb-Douglass functional form adequately represented the data set.

The second test conducted was, given such functional forms for the sample households; it was considered whether the technical efficiency levels were better estimated using an exponential normal or a half normal distribution of μ_i . The results indicated that the exponential distribution was appropriate for the sample households in the study area as the calculated LR value of 0.585 was less than the critical χ^2 value of 3.84 at 5% significance level.

The third hypothesis was test for the absence of inefficiency effect. In the case of half-normal and exponential models, the null hypothesis is a single restriction involving a single parameter. If the model has been estimated using the method of maximum likelihood, we can test such hypothesis using a simple z-test (because unconstrained ML estimators are asymptotically normally distributed). The null hypothesis $H_0: \ln(\sigma_u^2) = 0$ and the alternative hypothesis $H_1:$

$\ln(\sigma_u^2) > 0$, the test result which is the ratio of coefficient of $\ln(\sigma_u^2)$ to standard error of $\ln(\sigma_u^2)$ yields the value of 2.99 which is greater than the critical value of $Z_{0.05} = 1.96$ at (5% significance level). So we reject the null hypothesis of zero inefficiency effects.

The fourth hypothesis was about deciding on whether the explanatory variables associated with inefficiency effects are simultaneously equal to zero ($H_0: \delta_1 = \delta_2 = \dots = \delta_{13} = 0$) or not. The null hypothesis says that a model without explanatory variables of inefficiency effects while the alternative hypothesis says the full frontier model with the explanatory variables is supposed to determine inefficiency. The λ value obtained was again higher than the critical chi-square value at the degree of freedom equal to the number of restrictions. As a result, the null hypothesis is rejected in favor of the alternative hypothesis that the explanatory variables associated with inefficiency effects model are simultaneously different from zero. Hence, these variables simultaneously explain the difference in inefficiency among farmers.

4.9.2. Estimation of the production function

Prior to model estimation, a test was made for multicollinearity among the explanatory variables using the Variance Inflation Factor (VIF). In a production function analysis, the correlation between some of the explanatory variables is expected and collinearity among economic variables is an inherent and age-old problem leading to problems of multicollinearity. Some, therefore, have suggested that multicollinearity is not necessarily a problem unless it is very high (Gujarati, 1995). However, the values of VIF for all variables entered into the model were below 5 (Appendix Tables 1 and 2), which indicate the absence of severe multicollinearity among the explanatory variables. In addition, the Breusch-Pagan test was also used to detect the presence of heteroskedasticity and the test indicated that there was no problem of heteroskedasticity in the models. The result of the model showed that from the total of eight variables included in the Stochastic Frontier model the five variables have a significant and positive effect on the wheat output. Land under wheat production, labor, and NPS were significant at 1% significance level, seed and organic fertilizer were significant at 5% significance level. All of these significant variables have a positive effect on the level of wheat output. This means that the increase in these inputs would increase the output of wheat (Table 23). The coefficients of the production function are interpreted as elasticity. Hence, high elasticity of output to land (0.47) suggests that wheat

production was highly depending on size of land. As a result, 1% increase in size of land will result in 0.47% increase in wheat production, keeping other factors constant. Alternatively, this indicates wheat production was responsive to Land, labor, seed, NPS and organic fertilizer in the study area.

The result obtained on labor was inconsistent with the result of (Temesgen and Getachew, 2018) but the result on land and labor is similar to the result of (Hika, 2016; Mustefa *et al.*, 2017). As well as the obtained sign result on labor and organic fertilizer similar to the result of Beyan *et al.* (2013) but different sign result on seed obtained by the same authors.

Table 16: Estimation of the Cobb-Douglass frontier production function

Variables	Parameters	Coefficient	Sd. Error
Constant	β_0	1.63***	0.48
Ln(ox power)	β_1	0.10	0.08
Ln(land)	β_2	0.47***	0.08
Ln(labor)	β_3	0.34***	0.11
Ln(seed)	β_4	0.21**	0.08
Ln(urea)	β_5	0.09	0.07
Ln(NPS)	β_6	0.22***	0.06
Ln(Organic fertilizer)	β_7	0.02**	0.01
Ln(chemical)	β_8	0.10	0.09
Sigma square (σ^2)		0.19***	0.02
Lambda σ_u / σ_v		2.35	
Gamma (γ)		0.85	
Log-likelihood function		-119.32	

Source: own computation, 2019

The coefficient of σ^2 for the frontier of wheat output was 0.19 which was significantly different from zero at 1% level of significance. The significant value of the sigma square indicates the goodness of fit and correctness of the specified assumption of the composite error terms distribution (Idiong, 2005; Okoye *et al.*, 2007).

The ratio of the standard error of inefficiency component u (σ_u) to the standard error of residual v (σ_v), known as lambda (λ), which is 2.35. Based on λ , gamma (γ) which measures the effect of technical inefficiency in the variation of observed output can be derived (i.e. $\gamma = \lambda^2 / [1 + \lambda^2]$).

The result of the output briefly showed that γ is 0.846 implying that 84.6% of the total deviation of wheat output from the frontier level was due to the existence of technical inefficiency. While, the remaining 15.4% of the total variation of wheat output is due to random noises like unexpected rainfall, frost and other natural factors beyond the control of the farmers. Generally, this indicated that there was technical inefficiency so; the traditional production function is not an adequate representation of wheat production in this study.

According to Ajibefun, (2002) the returns to scale analysis can serve as a measure of total factor productivity. The return to scale coefficient was calculated to be 1.56 and it indicates increasing returns to scale (Table 23). This implies that there is potential for wheat producers to continue to expand their production because they are in the first stage of the production surface, where resource use and production is believed to be inefficient. In other words, a one percent increase in all inputs proportionally was increase the total production by 1.56%. Therefore, an increase in all inputs by 1% would increase wheat output by more than 1% in the study area. This result is consistent with the result of Ermias *et al.* (2015), Hika (2016) and (Asfaw *et al.*, 2019) but the obtained result is inconsistent with the result of (Awol, 2014; Fetagn, 2017).

The dual frontier cost function analytically derived from the stochastic production frontier shown in Table 23 is given by:

$$\ln C_i = 2.4 + 0.29 \ln C_{land} + 0.19 \ln C_{labor} + 0.12 \ln C_{seed} + 0.07 \ln C_{urea} + 0.14 \ln C_{NPS} + 0.01 \ln C_{organicfert} + 0.07 \ln C_{chem} + 0.003 \ln C_{Others} + 0.01 \ln Y_{Woutput} \quad (30)$$

Where C_i is the minimum cost of wheat production for the i^{th} farmer, $Y_{woutput}$ is total wheat output in quintal of the i^{th} farmer, C_{Land} is the rental price of land per hectare estimated at ETB 5000, C_{Labour} is the price of labor per day estimated at ETB 70, C_{Seed} is the price of seed per quintal estimated at ETB 1450, C_{urea} is the price of Urea fertilizer per Quintal estimated at ETB 1350, C_{NPS} is the price of DAP/NPS fertilizer per Quintal estimated at ETB 1500, $C_{Organic}$ is the price of organic fertilizer per Quintal estimated at ETB 150, C_{chem} is the price of chemicals per liter estimated at ETB 450, and C_{Others} is a price of other materials used in the wheat production.

4.9.3. Efficiency scores

The results of the efficiency scores indicate that there were wide ranges of differences in TE, AE, and EE among wheat producer farmers. The mean TE of sampled household heads during the survey period was 85.8%. The TE among the households ranges from 54.5% to 92.3%, with a standard deviation of 0.05. The mean AE of the sample households was 80.3%. The variation of allocative efficiency among sample household varies from 41.1% to 92.28%. Similarly, the mean EE of sampled household heads was 69%, which varies from 34.5% to 83.2%. Generally, there were huge variations inefficiency among wheat producer farmers in all measures of efficiencies. This result is consistent with the study by Ermias *et al.* (2015) and Mustefa (2014).

Table 17: Estimated technical, allocative and economic efficiency scores of the sample farmers

Variable	Mean	Std. Dev	Min	Max
TE	0.858	0.050	0.545	0.923
AE	0.803	0.120	0.411	0.928
EE	0.690	0.120	0.345	0.832

Source: own computation, 2019

The results in Table 24 indicate that the average level of TE was 85.8% which reveals that farmers on average could decrease inputs (land, labor, seed, NPS and organic fertilizer) by 14.2% to get the output they were currently obtained if they use inputs efficiently. Similarly, Wheat producer households can save 19.7% of their current cost of inputs if they use the right mix of inputs given their prices. Conversely, EE value of 69% shows that an economically efficient household can reduce his/her wheat production cost by 31%.

In the technical efficiency of most observations (70.4%) were found around the mean interval (80%-90%), 10.4% and 19.2% are below and above the mean interval respectively in the study area. Besides, the allocative efficiency distribution shows that about 51.72% is around the mean. 32.5% and 15.76% are below and above the mean interval respectively. The distribution of economic efficiency scores implies that the majority of the farmers 51.23% were performing in the interval (0.7–0.8] and about 19.21% are found in the lower bound interval of the mean. 19.11% and 10.34% are below and above the mean interval respectively.

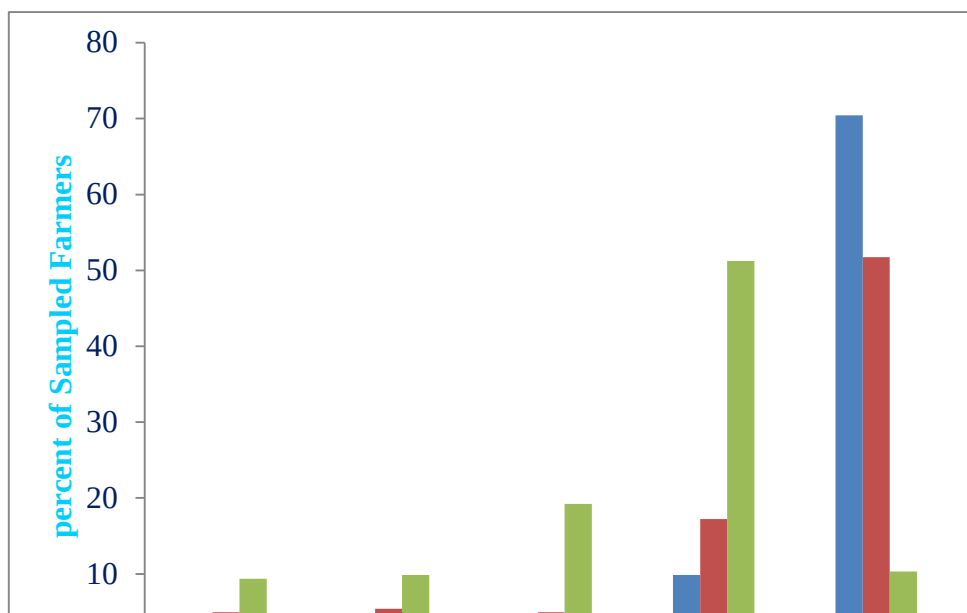


Figure 8: Efficiency scores distribution
Source: own computation, 2019

4.9.4. Determinants of efficiency differentials among wheat producers

The results obtained from the first stage estimation indicated that the average efficiency scores were not high enough and there exist efficiency variations among sampled farmers. The second objective of this study was to identify the factors that causing this variation between sampled farmers given using the same level of input as well as facing uniform input prices.

The Dependent variable; the technical, allocative and economic efficiency estimates derived from the frontier model were regressed on socio-economic, institutional and farm-related variables that explain variations in efficiency score by using a Tobit model.

Table 18: Factors causing efficiency variation between wheat farmers

	TE	AE	EE
Variables	ME(Std.err)	ME(Std.err)	ME(Std.err)
Sex(Dummy)	0.003 (0.003)	0.023 (0.032)	0.020 (0.027)
Family size	-0.001** (0.00)	-0.002 (-0.950)	-0.002 (0.002)
Farm experience	0.001*** (0.000)	-0.001 (0.001)	0.000 (0.001)
Education level	-0.001 (0.001)	-0.003 (0.003)	-0.003 (0.003)
Extension contact	0.000** (0.000)	0.002*** (0.001)	0.002*** (0.000)
Non-farm income	0.000 (0.000)	0.000*** (0.000)	0.016*** (0.006)
Credit	0.001** (0.000)	0.002*** (0.000)	0.003*** (0.000)
Land holding	-0.005** (0.002)	-0.002 (0.007)	-0.005 (0.006)
Cooperative membership(Dummy)	0.015*** (0.004)	0.029 (0.022)	0.039** (0.019)
Training(Dummy)	0.008** (0.003)	-0.021 (0.027)	-0.011 (0.023)
Average Distance from plots	-0.003*** (0.001)	0.006 (0.005)	0.003 (0.004)
Distance from market	0.000 (0.000)	-0.001* (0.001)	-0.001* (0.0006)
Distance from FTC	0.000 (0.000)	-0.005*** (0.002)	-0.004*** (0.001)
Time of sowing(Dummy)	-0.005 (0.004)	0.014 (0.025)	0.009 (0.021)
Method of sowing(Dummy)	-0.015*** (0.005)	-0.001 (0.027)	-0.014 (0.023)
Crop rotation(Dummy)	0.018*** (0.005)	0.003 (0.033)	0.017 (0.029)
Plots owner(Dummy)	0.050*** (0.015)	0.047 (0.030)	0.076*** (0.024)
Soil fertility(Dummy)	0.022*** (0.005)	0.035 (0.029)	0.046* (0.026)
Livestock	0.000 (0.000)	0.000 (0.002)	-0.001 (0.001)
Combiner(Dummy)	0.005** (0.003)	0.000 (0.012)	0.005 (0.010)

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

Source: Own computation results, 2019

The obtained model results for significant variables were discussed as follows:

Family size (FSadult): Family size was expected to have a positive effect on raising the farmer's efficiency. But the result obtained was against the expected one. Which was a family size in adult equivalent have a significant negative effect on the technical efficiency of sampled households; With the increase in family size expenditures on consumption and other expenses was increase and as a result it creates financial scarcity for timely and adequately purchasing of all the necessary agricultural inputs which in turn limits the production capacity and affect technical efficiency negatively. This result was consistent with the result of Endalkachew (2012), Ettah *et al.* (2017) and Nwike *et al.* (2017).

Experience of household head: The farming experience was also found to be statistically significant at 1% significance level. It had a positive effect on technical efficiency level. The sign of the variable is consistent with the expected sign. The result implies that farmers with longer experience of wheat production are more technically efficient as compared to those having lower production experience. This result is consistent with the result of Nwike *et al.* (2017) and contrary to the result obtained by Ettah *et al.* (2017).

Extension contact: Frequency of extension contact had a statistically significant positive relationship with technical efficiency at 10% significance level this implies that a frequent contact facilitates the flow of new ideas between the extension agent and the farmer thereby giving a room for improvement in farm efficiency. This result is consistent with the result of Musa *et al.* (2013) and Beyan *et al.* (2013).

It has also a significant positive effect on both allocative and economic efficiency at 1% significance level this result is as it was expected. The obtained result was consistent with the findings of Ermias (2013) and contrast with the result obtained by Musa *et al.* (2013).

Credit: It has a significant positive effect on the three types of efficiency. Which is at 1% significance level for allocative and economic efficiency and at 5% significance level for technical efficiency. The positive and significant impact of credit implies that credit availability enables farmers to make timely purchases of inputs that they cannot provide otherwise from their own resources. In other words, farmers who had access to credit were more technically,

allocative and economically efficient than farmers who had no access to credit. The result is similar with the result obtained by (Awol, 2014; and Musa *et al.*, 2015).

Nonfarm income: This variable is significant at 5 % significance level for economic efficiency with a positive coefficient. This may be because of; the availability of non-farm income shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs which they cannot provide from on-farm income. Therefore, it enables farmers to maximize their output at an efficient cost of production. It also had a significant positive effect on allocative efficiency of a wheat farmer and significant at 1% significance level. The obtained result was in agreement with the result of Asfaw *et al.* (2019).

Land holding: It is measured as total land cultivated by the farmer including those rented and shared in. In this study, it was hypothesized that land holding affects efficiency negatively. As the land holding of a farmer increases the managing ability of him/her was decrease given the level of technology, this lead to reduce the efficiency of the farmer. As expected this variable has a significant negative effect on technical efficiency. It has also negative coefficient for both allocative and economic efficiency; this implies that as the size of farm operation increase the ability of a farmer to use minimum input combination decrease and poor managerial ability to effectively utilize the total available land holding. This shows that a farmer operating in a large area is less efficient than farmers with small landholding size. The obtained result was contrary to the result obtained by Mustefa (2014) and (Gosa *et al.* (2016).

Cooperative membership: The result of this variable was as expected. It had a significant positive effect on both technical and economic efficiency at 1% and 5% significance level respectively. This might be due to the fact that farmers who were the member of cooperatives could afford the opportunity of interacting with other farmers thereby exchanging information on improved technology in farming. The obtained result was similar with the result of (Ettah *et al.*, 2017).

Training: This variable is obtained as expected on the technical efficiency of farmers. It was significant at 5% significance level and had a positive effect on technical efficiency. This could

be due to the fact that training improves the managerial as well as the technical ability of farmers. The technical efficiency of the trained farmers exceeded the technical efficiency of the untrained farmers by 0.8%. The result was similar to the result of (Getahun, 2014) and (Beyan *et al.*, 2013).

Distance between home and market: It had significant negative effect on the allocative and economic efficiency of wheat farmers at 10% significance level. Implies that as distance between home and market increase by 1km, allocative and economic efficiency of wheat farmer's fall by 0.1% keeping other factors constant. This is due to the fact that far distance of market from home of farmers affects information farmers receive on input and output price, leads farmers for high transportation cost and increase loading and unloading cost to farmers. The obtained result was consistence with the result of (Getachaw, 2018 and Alelign, 2017).

The average distance from Plot (Km): As it was expected, it has significant negative effect on the technical efficiency of wheat producers at 1% significance level. The distance between farm and farmers residence strongly affect their frequency of supervision, plant protection and application of organic fertilizer, especially animal dung, and manure. Because all these factors strongly decrease his/her technical efficiency level. The result was similar to the result of (Wellie, 2017).

Distance from FTC: It was expected to affect efficiency negatively. The obtained result was as expected for economic and allocative efficiencies. Because farmers' training centers (FTC) provide farmers with new information, training, and demonstrations to encourage best farming practices. The obtained result is consistent with the result of (Alelign, 2017).

Crop rotation: This variable is significant at 1% significance level and has a significant positive effect on technical efficiency. The technical efficiency of farmers who practice crop rotation is increased by 0.02 scores as compared to those farmers who not practicing crop rotation. Therefore, practicing crop rotation especially wheat with legume crops can increase soil fertility so as to increase the technical efficiency of wheat producers by increasing its production. This finding was similar to the result obtained by (Mustefa, 2014) and contrary to the result of (Musa, 2013) and (Wellie, 2017).

Plot Ownership: Plot ownership measured in terms of the dummy was found to determine the technical and economic efficiency level of farmers in producing wheat positively and significantly at 5% and 1% of significance level respectively. Farmers who used their own land for wheat production are more efficient than farmers who manage rented and sharecropped land. This implies that, farmers who produce on their own land-use inputs properly and give priority during farming periods than who manages sharecropped land. In addition, the sharecropping arrangement was not encourage the operator farmer to take a risk as the risk of the loss of returns on inputs solely taken by the operator farmer. The obtained result was similar to the result of (Kifle *et al.*, 2014). The result obtained on technical efficiency was consistent with the result of (Aseffa, 2016).

Soil fertility: It had a positive as well as a significant influence on technical and economic efficiencies at 1% and 10% levels of significance, respectively. It means that the technical and economic efficiencies of farmers having fertile land as compared to those individuals having infertile lands increase by 2.2% and 4.6%, respectively keeping other factors constant. The result was consistent with the finding of Mustefa (2014) and Asfaw *et al.* (2019) and inconsistent with the result obtained by (Wellie *et al.*, 2018).

Combiner: It has a significant positive effect on technical efficiency, which is at 5% significance level. The obtained result was as expected. This is due to the fact that the use of technology has great improvement in the technique of the farmers than human and animal power. The obtained result was similar with the result of (Kusse *et al.*, 2018).

5. SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1. Summary and Conclusion

As compared to the other Africa countries the Ethiopia wheat production and productivity were low. Ethiopia is one of the resource full counties; even though the country based on wheat imports to feed its population. Previously in the study area, there is limited empirical study on the Efficiency and productivity level of wheat producer. This study tried to fill the gap with the general objective of the study; assessing the economic efficiency of smallholder wheat producer in the Robe District of Arsi zone, Oromia Regional State, Ethiopia. Specifically to estimate the level of technical, allocative and economic efficiencies of wheat farmers and to identify factors affecting technical, allocative and economic efficiencies of wheat production in the study area.

A two-stage random sampling procedure was employed; in the first stage, six kebeles were selected from a total of 32 wheat producer kebeles. In the second stage; 203 wheat producer farmers were selected. The required cross-sectional data were gathered from both primary and secondary data sources. The collected data were analyzed by using both descriptive statistics and econometric model for the estimation of efficiency score and efficiency variation. The stochastic frontier model with the specification of Cobb-Douglass logarithmic functional forms of the production function was used to predict technical efficiency and the use of self-dual production frontier allows the cost frontier to be derived and used to estimate economic efficiency. allocative efficiency was derived from TE and EE result. The SFA approach was chosen as it best suits a single output and multiple-inputs production programs and as it easily incorporates inefficiency and random component effects into the model. While variables that cause inefficiencies discrepancy among wheat-producing farmers in the study area were identified by using the Tobit Model.

The estimated result from Cobb-Douglass frontier production function showed that Land under wheat production, Labor, NPS, Seed, and Organic fertilizer have a significant positive effect on the wheat output. This implies that the improvement in these inputs would increase wheat output level. The coefficients of the Cobb-Douglass production function are interpreted as the degree of

responsiveness of relative change in wheat output due to simultaneous change in all inputs (elasticity) and summing the individual elasticity yields a scale elasticity of 1.56 this implies that the production of wheat out by sampled farmers were found in the first stage of production surface where resource use and production is believed to be inefficient. Based on economic theory assumption in this stage there is potential for wheat producers to continue in expanding their production.

The study also indicated that there were variations in the TE, AE, and EE among wheat producer farmers. The mean TE, AE, and EE of sampled household heads during the survey period were 85.8%, 80.3% and 69% respectively. This, in turn, implies that farmers can increase their wheat production on average by 14.2% when they were technically efficient. Similarly, they can reduce the current cost of inputs, on average, by 19.7% if they were allocatively efficient. Inside of economic efficiency; an economically efficient household head can reduce his/her wheat production cost by 31%. This implies that using the existing resource base, improves efficiency can still be achieved and there was a great potential for increasing the gross output and profit with the existing level of the resource base.

The results from Tobit model also revealed that among twenty variables incorporated into the model; farm experience, frequency of extension contact, amount of credit, soil fertility, cooperative membership, crop rotation, training, combiner and plot ownership had significant positive effect on technical efficiency. While it has an inverse relationship with the family size in adult equivalent, total landholding operated, plot distance and method of sowing. Allocative efficiency, the ability to use least-cost combination of inputs to produce a given level of wheat output was positively affected by the frequency of extension visit, amount of credit used and nonfarm income. As well as allocative efficiencies were negatively affected by distance from the farmer training center and distance from market. On the other hand, frequency of extension visit, amount of credit used, nonfarm income, soil fertility, cooperative membership, and plot ownership significantly and positively affects the level of economic efficiency. As well as it was significantly and negatively affected by distance from farmer training center and distance from market.

Generally, the positive value of the marginal effect of different demographic, socio-economic, farm characteristics and institutional factors indicate that any improvements made on these variables would increase the efficiency of wheat-producing farmers or the positive value of marginal effect indicated that; motivation of these variables would absolutely aggregate inefficiency gap among farmers in the study area.

5.2. Recommendations

The overall findings of this study showed that the presence of economic efficiency variation among the farmers and also showed that there is a wide opportunity to increase their level of wheat output by using the current input available as well as they can improve Efficiency level through minimizing the cost of production without compromising wheat yield. In order to be more efficient farmer in the wheat production, the following policy should be forwarded

Land and seed had a significant positive effect on wheat output; even though the increment of wheat output by expanding area is possible nowadays availability of land become extremely limited because of scarcity. Therefore the improvement of wheat output should be concerned by the increasing amount of wheat seed and improvement in the management practices (such as weeding system, pest and disease control).

The experience as a proxy to the age of household head showed a positive and significant effect on technical efficiency. This may be due to experience adopted over the years of farming activity. Therefore, the woreda agricultural sector experts and any concerned body should encourage farmers with little experience (low age farmers) to share the experience with the experienced ones (higher age farmer) or train them to be in the same farmer's cooperative.

Frequency of extension visit and the amount of credit had a positive and significant effect on the three types of efficiencies. The credit facilities should be available to the wheat producers through any formal institutions on easy terms and conditions as well as the proper time of repayment to meet the cash requirements for wheat production.

Income from non-farm activity had a positive and significant effect on the allocative and economic efficiencies. This implies that financing timely and enough use of inputs through additional income generated by non-farm is critical. Therefore, strategies that encourage the use of non-farm employment opportunities would help to increase the timely and appropriate use of inputs for better efficiency in wheat production in the study area.

Soil fertility and cooperative membership affect technical and economic efficiency positively. Therefore, the amendment of soil fertility status by applying organic fertilizer (which have a significant positive effect on wheat out) and practicing different soil conservation techniques should have to done by farmers.

Steps should be taken to motivate the farmers to adopt crop rotation (Grain followed by legumes) in their wheat production to add nutrients that wanted by crops in the long run and increase the wheat yield. In addition, extension workers in the study area can play a great role in improving the soil fertility status by working closely with the farmers.

Family sizes in adult equivalent have a significant negative effect on technical efficiency. Therefore to be technically more efficient; family planning strategies should be adopted by the household heads.

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7. APPENDICES

7.1. Appendix Section I Tables

Table in appendix 1. VIF for the variables used in the estimation of Cobb-Douglass production function parameters and technical inefficiency component by stochastic frontier model

Variables	VIF	1/VIF
Land for Wheat	2.59	0.39
Amount of Seed	2.20	0.45
Amount of Urea	1.65	0.61
Labor	1.41	0.71
Chemical	1.20	0.83
Oxen power	1.12	0.89
DAP(NPS)	1.06	0.94
Organic Fertilizer	1.05	0.95
Mean VIF	1.54	

Source: own computation, 2019

Table in appendix 2. VLF for the variables entered into the efficiency model

Variable	VIF	1/VIF
Sex**	1.13	0.89
Family size	1.25	0.80
Farm experience	1.52	0.63
Education Level	1.27	0.78
Frequency of extension contact	1.48	0.64
Nonfarm income	1.59	0.63
Amount of credit used	1.74	0.58
Total landholding	1.25	0.78
Cooperative membership**	2.73	0.37
Training**	3.21	0.31
Plot distance	1.97	0.47
Distance from market	1.59	0.62
Distance from farmer training center	1.61	0.62
Time of sowing**	1.12	0.89
Method of sowing**	2.10	0.48
Crop rotation**	4.33	0.21
Plot ownership**	1.22	0.82
Soil fertility**	4.07	0.25
Livestock in TLU	1.34	0.75
Combiner	1.39	0.72
Mean VIF	1.89	

** indicate the variable is Dummy

Table in appendix 3. Conversion factor for computation of adult equivalent ratio for family size

Age group	Man equivalent		Adult- equivalent	
	Male	Female	Male	Female
<10	0	0	0.6	0.6
11-13	0.2	0.2	0.9	0.8
14-16	0.5	0.4	1	0.75
17-50	1.0	0.8	1	0.75
>50	0.7	0.5	1	0.7

Source; Storck, et al. (1991)

Table in appendix 4. Conversion factors used to estimate tropical livestock unit (TLU) equivalents

Animal Category	TLU
Ox and Cow	1
Heifer	0.75
Weaned Calf	0.34
Calf	0.25
Horse and Mule	1.10
Donkey(young)	0.35
Donkey(adult)	0.70
Sheep and Goat(young)	0.06
Sheep and Goat(adult)	0.13
Chicken	0.013
Camel	1.25

Table in appendix 5. Efficiency Scores of Sample Farmers (SPF)

HH ID	TE	AE	EE	HH ID	TE	AE	EE
1	0.866377	0.901608	0.781133	103	0.891581	0.849807	0.757672
2	0.841367	0.753536	0.634001	104	0.839932	0.739269	0.620936
3	0.892265	0.878708	0.784041	105	0.888538	0.887339	0.788434
4	0.856636	0.819529	0.702038	106	0.889323	0.919343	0.817593
5	0.853712	0.871055	0.743632	107	0.886259	0.853059	0.756031
6	0.823171	0.913488	0.751957	108	0.708129	0.894534	0.633591
7	0.907365	0.867102	0.786778	109	0.900813	0.819099	0.737854
8	0.851971	0.863474	0.735654	110	0.545232	0.716715	0.390609
9	0.886983	0.754481	0.669211	111	0.821102	0.454532	0.373217
10	0.832181	0.827118	0.688311	112	0.857336	0.438767	0.376172
11	0.842004	0.919842	0.774511	113	0.833819	0.883268	0.736486
12	0.883253	0.878737	0.776148	114	0.846563	0.835189	0.707041
13	0.823642	0.862851	0.71068	115	0.859187	0.884579	0.760019

14	0.785871	0.855248	0.672114	116	0.829647	0.415382	0.344621
15	0.901882	0.919937	0.829675	117	0.875544	0.922842	0.807989
16	0.907494	0.884338	0.802531	118	0.784769	0.497981	0.3908
17	0.901015	0.851768	0.767455	119	0.831319	0.479392	0.398527
18	0.908486	0.911839	0.828393	120	0.748184	0.798231	0.597224
19	0.914773	0.909295	0.831798	121	0.843012	0.6685	0.563553
20	0.918233	0.893617	0.820549	122	0.881923	0.895195	0.789493
21	0.893025	0.890491	0.795231	123	0.853071	0.873723	0.745347
22	0.886229	0.710343	0.629527	124	0.745282	0.828913	0.617773
23	0.912989	0.736887	0.67277	125	0.782878	0.801753	0.627675
24	0.899697	0.887362	0.798358	126	0.887014	0.836188	0.74171
25	0.901372	0.80775	0.728084	127	0.773032	0.530531	0.410116
26	0.905485	0.904508	0.819018	128	0.843776	0.903998	0.762771
27	0.899471	0.883075	0.7943	129	0.890161	0.680683	0.605917
28	0.854744	0.800709	0.684401	130	0.705746	0.792765	0.559491
29	0.861929	0.894926	0.771362	131	0.788741	0.870424	0.686539
30	0.894835	0.831954	0.744462	132	0.821058	0.429386	0.352551
31	0.855285	0.881264	0.753732	133	0.822492	0.849211	0.698469
32	0.865165	0.918021	0.794240	134	0.891657	0.872975	0.778394
33	0.851004	0.919086	0.782146	135	0.888185	0.911746	0.814874
34	0.851504	0.860447	0.732674	136	0.901367	0.864416	0.779157
35	0.864817	0.900711	0.778951	137	0.894486	0.798727	0.714451
36	0.854563	0.860073	0.734987	138	0.865373	0.410562	0.355289
37	0.885702	0.846031	0.749332	139	0.774779	0.917872	0.711148
38	0.876525	0.912213	0.799654	140	0.834731	0.916923	0.765384
39	0.817851	0.918516	0.751210	141	0.853719	0.901802	0.769886
40	0.878725	0.916579	0.805421	142	0.868656	0.892944	0.775661
41	0.788039	0.889653	0.701081	143	0.827760	0.469855	0.388927
42	0.767989	0.726125	0.557656	144	0.863142	0.89132	0.769336
43	0.866792	0.790936	0.685577	145	0.880912	0.902151	0.794716
44	0.906773	0.896037	0.812502	146	0.813040	0.480524	0.390685
45	0.904241	0.918528	0.830571	147	0.847605	0.551418	0.467385
46	0.879206	0.850511	0.747775	148	0.891362	0.822803	0.733415
47	0.897544	0.779884	0.699981	149	0.845339	0.592167	0.500582
48	0.914005	0.767373	0.701383	150	0.900630	0.782209	0.704481
49	0.918363	0.894123	0.821129	151	0.808541	0.854881	0.691206
50	0.893963	0.792594	0.708552	152	0.873075	0.820838	0.716653
51	0.903896	0.885128	0.800064	153	0.701998	0.563181	0.395352
52	0.870120	0.827358	0.719901	154	0.723014	0.569816	0.411985
53	0.906316	0.820225	0.743383	155	0.860321	0.546061	0.469667
54	0.903514	0.696127	0.628962	156	0.829302	0.710359	0.589103
55	0.912780	0.807741	0.73729	157	0.857346	0.478388	0.410144
56	0.902345	0.876435	0.790847	158	0.844644	0.793995	0.670643
57	0.879797	0.652848	0.574374	159	0.808212	0.689679	0.557407
58	0.819912	0.863726	0.708179	160	0.832776	0.921688	0.76756

59	0.835909	0.920115	0.769133	161	0.90555	0.904781	0.819324
60	0.803975	0.865892	0.696155	162	0.890688	0.917913	0.817575
61	0.870561	0.730698	0.636117	163	0.913362	0.880985	0.804658
62	0.900725	0.838274	0.755054	164	0.905163	0.886421	0.802356
63	0.851478	0.877020	0.746763	165	0.901712	0.79498	0.716843
64	0.884048	0.753616	0.666233	166	0.907007	0.824299	0.747644
65	0.896297	0.840014	0.752902	167	0.862854	0.828811	0.715142
66	0.787268	0.844676	0.664987	168	0.846721	0.895783	0.758478
67	0.861804	0.792501	0.682981	169	0.904146	0.828050	0.748678
68	0.841519	0.805801	0.678097	170	0.905366	0.873978	0.79127
69	0.809233	0.852197	0.689626	171	0.856312	0.872652	0.747263
70	0.806074	0.700521	0.564671	172	0.899680	0.576715	0.518859
71	0.867813	0.601079	0.521624	173	0.896620	0.606543	0.543839
72	0.865390	0.904634	0.782862	174	0.870389	0.881303	0.767076
73	0.894124	0.916274	0.819263	175	0.839531	0.632309	0.530843
74	0.872073	0.639721	0.557883	176	0.917586	0.848292	0.77838
75	0.873850	0.840957	0.73487	177	0.866966	0.914555	0.792888
76	0.815466	0.722497	0.589171	178	0.902081	0.891618	0.804311
77	0.80343	0.720926	0.579213	179	0.861746	0.774470	0.671822
78	0.840804	0.753902	0.633884	180	0.901141	0.836145	0.753484
79	0.832887	0.824041	0.686333	181	0.867866	0.878818	0.762696
80	0.833275	0.548196	0.456798	182	0.798087	0.817392	0.652349
81	0.888277	0.517977	0.460107	183	0.881635	0.863681	0.761452
82	0.867163	0.862509	0.747936	184	0.892259	0.826632	0.737843
83	0.862108	0.666929	0.574964	185	0.911152	0.875934	0.798109
84	0.908048	0.856704	0.777929	186	0.823144	0.888630	0.73147
85	0.895514	0.574547	0.514514	187	0.834339	0.771802	0.643945
86	0.87861	0.820524	0.720921	188	0.756342	0.787370	0.595583
87	0.848947	0.806383	0.684577	189	0.922301	0.886416	0.81817
88	0.887619	0.865605	0.768328	190	0.895431	0.782589	0.700755
89	0.899764	0.882927	0.794426	191	0.885775	0.789561	0.699374
90	0.904020	0.869439	0.785990	192	0.840278	0.736395	0.618777
91	0.777601	0.761406	0.592070	193	0.899540	0.820424	0.738004
92	0.795147	0.813332	0.646719	194	0.907321	0.878914	0.797457
93	0.882224	0.889550	0.784782	195	0.860531	0.883650	0.760408
94	0.879771	0.875807	0.770509	196	0.890410	0.726139	0.646562
95	0.782540	0.900221	0.704459	197	0.803342	0.779378	0.626108
96	0.877961	0.823287	0.722814	198	0.800332	0.594702	0.475960
97	0.847477	0.841125	0.712835	199	0.808027	0.918821	0.742432
98	0.871683	0.858775	0.748580	200	0.822922	0.812123	0.668314
99	0.909840	0.801066	0.728841	201	0.867868	0.860348	0.746668
100	0.839754	0.736113	0.618154	202	0.888369	0.894538	0.794680
101	0.867896	0.893823	0.775746	203	0.854446	0.847289	0.723963
102	0.827796	0.912763	0.755582				

Source; own computation (2019)

7.2. Appendix Section II. Survey Questioner

Household questioner: Determinants of Economic Efficiency on wheat Production: The Case of Robe District, Arsi Zone, Oromia National Regional State, Ethiopia

Instruction: Tell the purpose of the study and introduce yourself before starting interview. For all closed questions put (X) mark where appropriate for choices circle the answers and use the space provided for open-ended questions.

Date of interview _____ Identification Number _____

PART I. General Information about Sample Farmers

1. Name of Respondent: _____ Sex _____ Age _____ Kebele _____
2. Education level of the respondent (X): 1. Illiterate 2. If attend school grade _____ 3. Certificate
4. Diploma 5. Degree
3. Marital status (X): 1. Married 2. Single 3. Divorced 4. Widowed
4. Respondent's religion: 1. Muslim 2. Orthodox 3. Protestant (4): Other: _____
5. Years of experience in wheat production _____ years
6. Number of family Size: how many family member you have? Total _____ numbers
7. Please indicate in which age group your family member found; fills the following table

Sex	< 10Yrs	[10-13] Yrs	[14-16] Yrs	[17-50] Yrs	Above 50 Yrs
Male					
Female					

PART II: General Information about the wheat farming

1. Do you have own land for crop production and animal rearing? 1. Yes 2. No
2. If yes, Total Area of land _____ (ha) a) Cultivated land _____ timad b) Grazing land _____ timad c) Homestead land _____ timad d) Other land, specify _____ timad. (Note: 1 ha equates 4 timad use local conversion rate if it is different and specify it).
3. Main crops grown with their total production and market price in the area during 2018/19 production season

Name of crops	Allocated land (ha)	Product ion (Qt)	Amount of crop output that sold	Unit Price	Type of Seed used		
					If Local (amount in Qt)	If Improved (amount in Qt)	If seed were bought unit price
Wheat							
Teff							
Maize							
Barley							
Bean							
Pea							
Sorghum							
Oilseed							
Nug							
Others specify							

4. At what time did you start land preparation? _____month.
5. How many times do you plough your wheat land? _____
6. At what time did you sow wheat? _____month.
7. Which method of sowing you used in wheat sowing? 1. Broad Band maker 2. Row planting
8. How many pairs of oxen did you apply from land preparation up to planting? _____
9. Is weeding wheat crop a common practice? (1). Yes (2). No
10. If yes, when you start weeding wheat? -----Week of -----month
11. How many times do you weed? _____times.
12. What method do you use for weeding? 1. Hand weeding 2. Hoeing 3. I use chemicals 4. Others, specify _____
13. If you use chemical in the weeding and keeping diseases and pests from your wheat crop fill the following table

No	Name of Chemical	Amount used(a)	Unit (litter)	Price per unit(b)	Total cost(a*b)
1					
2					
3					
4					
5					

14. When did you harvest your wheat crop? _____month

15. How many quintals of wheat yield did you received this year? -----Qt

16. How is the trend of volume of wheat crops production during the past 3 years? _____

17. Did you use combiner in your harvesting wheat? 1. Yes 2. No

18. If answer for Question (no. 17) is yes, fill the following table

Amount of wheat output harvested by combiner(a)	Price per unit(b)	Total cost(a*b)

19. If answer for Question (no. 17) is No what are the reason not to use combiner?

20. Have you involved in share cropping and land rent? 1. Yes 2. No

21. If yes for (Qn no 20), fill the following table, what is the size and rate of land?

Description	Size (Ha)	In kind	In cash(unit price)	For share in Proportion (ratio) A*
Share in		X		
Share out		X		
Rent in			X(_____)	
Rent out			X(_____)	

A* 1.Equal 2. One-second 3. One-third 4. One-fourth 5. Other, specify.....

22. How many plots did you use to produce all crops in the year 2018/2019 production season?

23. How many plots did you use to produce wheat in the year 2018/2019 production season?

24. How is the soil fertility status of your wheat plot? Fill the following table

No. of Plot	Size of plot	Fertility status(Code A)	Time it take to reach plot(Hrs)	Distance from home(Km)
Plot1				
Plot2				
Plot3				
Plot4				
Plot5				
Plot6				
Plot7				

Code A: 1.HighlyFertile 2. Fertile 3. Infertile 4. Poorly fertile

25. Do you own wheat plot land? 1. Yes 2. No

26. Did you practice Crop rotation for your wheat plot? 1. Yes 2. No

27. If “Yes” for (Qn 26) which type of crop follows before and after wheat crop? _____

28. If “No” for (Qn 26) why you not adapt crop rotation?_____

29. How is the slop of your wheat plot? 1. Flat 2. Steep 3. Other

30. Which method you have used in preserving soil from flood? _____

PART. III. Inputs used in the Wheat Production by Farmers.

Labor: 1. what is the source of labor used for wheat production? 1. Family labor 2. Labor exchange 3. Hired labor 4. Cooperation 5. Others specify_____

2. The source of oxen power: 1. Own 2. Rent 3. Other (specify)_____

3. Do you face labor shortage for wheat farming activities? 1. Yes 2. No

4. If yes, for which operation? 1. Plowing 2. Planting 3. Weeding 4. Harvesting 5.Threshing 6. Others _____

5. How do you overcome labor shortage? 1. Hired labor 2. Debo 3. Wonfel 4. Other, specify_____

6. If you overcome by hired labor, indicate the payment made to labour in 2018/19. 1. Wage 2. Salary 3. Other specify_____

7. How do you overcome oxen shortage? 1). by rented in 2). By exchange 3). Others, specify __

8. If you overcome by rented in, indicate the payment made to oxen labour in 2018/19. ____ETB

Fertilizer: 1. Do you use chemical fertilizer in wheat field? (1). Yes (2). No

2. If yes, what type of fertilizer? 1. DAP 2. Urea 3. Both 4. Other, specify-----

3. How many Quintal of chemical fertilizer you have used for wheat production for one hectare of wheat plot? 1. _____Ha/Qt DAP 2. _____ Ha/Qt Urea

4. What is the unit price of fertilizer you have used? 1. NPS_____ETB/Qt 2. Urea_____ETB/Qt 3. Total Cost_____ ETB/Qt (amount used*Unit Price)

5. What is the application method of fertilizer and seed is used in sowing of wheat? 1. Broadcasting 2. Row planting

6. Do you get fertilizer on time? 1. Yes 2. No

7. How far do you travel to buy fertilizer? -----Minute -----hrs.

8. What type of transport do you use to transport fertilizer from market center to your

9. If you have ever encountered problems with the use of fertilizer and improved seeds, what are the problems you faced? _____

PART IV: Extension Service, Credit, Training, Cooperative, Marketing, other Social Institutions and off farm Income

1. Extension services

1.1. Did you get an extension service? 1. Yes 2. No

1.2. If yes, average frequency of contact with DA and extension professions in 2018/19_____ times in week?

1.3. How many times did you meet with the extension workers? 1. Daily 2. Weekly 3. Monthly 4. Biweekly 5. Never contact

1.4. Where did you meet with the extension workers? 1. at his/her office 2. At plot area 3. At sudden meeting 4. Others specify_____

1.5. Distance from extension agents office_____minutes _____Km.

2. Credit Service:

2.1. Have you access to credit? 1. Yes 2. No

2.2. If “Yes” Did you borrow money this season? 1. Yes 2. No

2. If “Yes” how much do you borrowed ----- ETB.

3. If you borrowed, from where and for what purpose did you collect the credit?

4. If “No” What are the problems behind not using credit? _____

3. Training

3.1. Did you get training on specifically with regard to wheat production practices before? 1. Yes
2. No

3.2 If ‘yes’ for (Qn3.1) what type of training you received? _____

3.3. If ‘No’ for (Qn3.1) why you not get the training? _____

3. 4. How much training on crop production have you taken so far? _____

3.5. Is there farmer-training center in your area? 1. Yes 2. No

3.6 If “No” for (Qn3.5) what was the reason? _____

4. Cooperative

4.1is there any cooperative organization in your locality? 1. Yes 2. No

4.2. If yes what are their names? _____

4.3. Are you a cooperative membership? 1. Yes 2. No

4.4 If ‘yes’ for (Qn4.3) what is the name of your cooperative organization?

4.5 If ‘No’ for (Qn4.3) what are the reason that prohibit you to be a member?

5. Marking infrastructure and accessibility

5.1. How many quintals of wheat did you produce in 2018/19production year? _____

5.2. For what Purpose did you produce wheat? 1. All for sale 2. All for consumption 3. Partly
for consumption and partly for sale

5.3. If your answer is choice ‘3’ how many quintals did you sell? _____

5.4. What was the average selling price? _____ ETB/qt

5.5. Do you have unsold wheat output waiting for good market season? 1. Yes 2. No

5.6. If yes, how many? _____ Quintals.

5.7. In which month/s do you expect to sell _____ & at what price? _____ ETB/qt.

5.8. If ‘yes’ for (Qn5.5) for, what marketing problems are you facing? 1. Low price 2. High seasonal price fluctuation 3. Inadequate demand 4. High marketing cost 5. Lack of market information 6. Credit sale

5.9. Again, if ‘yes’ for (Qn5.5) what do you think will be the solution?

5.10. How many minutes it take to reach the near market? _____ minute _____ Km

5.11. How many minutes it take to reach the town market? _____ minute _____ Km

6. Social Institutions

6.1. Is there any informal or formal social institution in your locality? 1. Yes 2. No

6.2. If yes, mention the major social institution 1. Input supply coop./union 2. Local administration 3. Edir 4. Equb 5. Saving and credit association 6. Other, specify _____

6.3 Do you participate in social institutions? 1. Yes 2. No

6.4 If (Qn6.3) yes, what is your role? 1 Leadership 2. Committee 3. Member 4. Other, specify _____

6.5 What is the most purpose of this group functions? 1. Input access 2. Saving and credit 3. Funeral group 4. Produce marketing 5. Support people at critical problem 6. Others specify _____

6.6 Does your responsibility have significant negative impact in farming activities? 1. Yes 2. No

6.7 How many days on average do you spend per month to in your responsibility? _____

6.8 Who will take care of the farming activities while executing your responsibility? 1. Family members 2. Hired workers 3. Relative's 4. The society 5. Other, specify _____

6.9 If not member of social institution, why? 1. Because organization was not useful 2. Poor management 3. Ceased to exist 4. Other, specify _____

7. Income from off/non-farm Activity and Livestock Ownership

7.1. Do you have any source of income other than farming? 1. Off/non-farm activity 2. Pension payments 3. Constant transfer payment 4. Salary/wage 5. Rent from asset or real estate 6. Other specifies _____

7.2. Did you perform other Off/non-farm income generating activities? 1. Yes 2. No

7.3. If yes, how many of your family members are engaged in Off/non-farm activities?
Male _____ female _____

7.4. Why some members of your family are engaged in Off/non-farm activities? 1. Shortage of land 2. Excess family labor 3. Attractive income from off/non-farm activities 4. Other, specify _____

7.5 What amount of income you get from non-farm activity? _____ ETB

7.6. Fill the following table for your type of Livestock owned and not owned

Type of Animal	Number		Its price in ETB	Remark
	Own	From others		
Ox				
Cow				
Heifer				
Bull				
Calves				
Horse				
Mule				
Donkey				
Sheep				
Goat				
Chicken				
Others				

PART V: Main Problems Faced by farmers in wheat production

1. Please state the major problems encountered in wheat production?

Thank you for sharing your experience!!!