2020-09-04

Technical Efficiency Analysis of Wheat Production in Yilmana Densa District

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FEB, 2020

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BY
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A THESIS SUBMITTED TO THE DEPARTMENT OF ECONOMICS, COLLEGE OF BUSINESS AND ECONOMICS, BAHIR DAR UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN DEVELOPMENT ECONOMICS

FEB, 2020
BAHIR DAR

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ACKNOWLEDGEMENT

First, my heartfelt gratitude goes to my research advisor Prof. Jayamohan MK.for his invaluable and stimulating support. I greatly acknowledge his interesting assistance and provision of important comments to accomplish this work, without his encouragement the thesis work would not have been completed. Second, I express my authenticity gratitude to all my family, especially my mother, for their patience and support my stay out of home all the time. I would like to thank the Yilmana Densa agriculture and development office workers who help me in the data collection process. Lastly, I would like to express special thanks Zelalem Ayalew, MA in TEFL who support me in editing and grammar checking.

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LISTS OF ACRONYMS

ACSI	Amhara Credit and Saving Institution
CSA	Central Statistical Agency
DEA	Data Envelopment Analysis
G.C	Gregorian Calendar
EDHS	Ethiopian Demographic and Health Survey
EEA	Ethiopian Economic Association
GDP	Gross Domestic Product
MoFED	Minister of Finance and Economic Development
NBE	Nation Bank of Ethiopia
SPF	Stochastic production Frontier
SNNP	Southern Nations Nationalities and Peoples
YDARoD	Yilmana Densa Agricultural and Rural Development Office
HDI	Human Development Index
HDR	Human Development Report
OLS	Ordinary Least Square
TE	Technical Efficiency
TI	Technical Inefficiency
Ha	Hectare
FTC's	Farmers Training Centers
COLS	Corrected Ordinary Least Square
MLE	Maximum Likelihood Estimation

ABSTRACT

This study is conducted to analyze technical efficiency of wheat production in Yilmana Densa District during the 2019 production year. The study is conducted using across-sectional data collected from 194 sample households based on multistage random sampling technique. The stochastic production frontier and Tobit model were applied to address the objectives. The estimated stochastic production frontier model reveals that the input variables like labor, oxen, improved seed and chemical fertilizer were the significant variables to increase the quantity of wheat output. The mean level of technical efficiency in the study area is 37 percent, indicating that the production of wheat can be increased by 63 percent given the existing technological level. The discrepancy ratio gamma indicated that 96 percent of the total variation from the frontier comes due to technical inefficiency while the remaining 4 percent comes due to factors outside of farmer's control. Among the factors that affect technical efficiency; sex, age, secondary school education, extension contact, proximity, and membership affects technical inefficiency negatively. Besides, age square, family size, amount of credit, land fragmentation, illiterate, primary school education and manure application influence technical inefficiency positively. Hence, emphasis should be given to decrease the inefficiency level of farmers through enabling them to get support by extension experts on the way of the utilization of improved seed and sufficient fertilizer instead of only their provision.

Keywords: Stochastic frontier, Technical efficiency, Wheat, Yilmana Densa, District

1. INTRODUCTION

1.1 Background of the Study

Agriculture has been the basis for the livelihood of most Ethiopian people. It is an important sector for the Ethiopian economy. The sector plays a great role in the development process of a country by supplying food items and industrial inputs, generating foreign exchange, creating employment opportunities, expanding market for industrial output and contributing to gross domestic product (GDP).

More than14 million farm households in Ethiopia account for 95 percent of agricultural production and 80 percent of employment (CSA, 2013). The sector comprises nearly 42 percent of the country's total GDP, 90 percent of the export earnings and 85perecent of the labor force (CSA, 2016). Recently, In terms of structural change, the share of Ethiopian agriculture and allied activities in overall GDP contribution which was about 42 percent at the beginning of the plan period (2009/10) declined to 38.8 percent by the end of 2014/15. This is an indication of a structural shift from agriculture to industry and the service sector. Although the service sector surpasses the agricultural sector in recent years in GDP contribution, the role of agriculture is still noteworthy (NBE, 2014).

In the agricultural sector crop subsector comprises the lion share of agricultural production which cereal crops take the principal role. Besides, cereal accounts for 87.3 percent of the total grain production of 270.4 million (NBE, 2014). Cereals also comprise approximately 60 percent of rural employment, 80 percent of cultivated land, more than 40 percent of household's food expenditure and more than 60 percent of total caloric intake (World Bank, 2007).

Wheat which is one of the major cereal food crops produced in Ethiopia is the fourth largest cereal crop produced by close to 5 million smallholder farmers (Samuale et al., 2017) and it is the third productive cereal crop next to maize and sorghum (Abera et al., 2005). Among other cereal crops produced in the country, wheat consists 18.2 percent of cultivated area and 19.8 of cereal crop production (Getahun, 2013) and on average, the yield of cereal crops was 1.55 tons per hectare while that of wheat was 1.83 tons per hectare (Hanan et al., 2017). This shows that the country has potential for wheat production per hectare. It is estimated that 4.7 million farmers produce 3.9 million tons of wheat across 1.6 million hectares of land with an average productivity of 2.4 tons per hectare (CSA, 2014).

In Ethiopia, the major wheat-producing zones are Arsi, Bale, Shewa, Ilubabor, Western Harerghe, Sidamo, Tigray, North Gonder, and Gojam. According to EEA (2017), the major wheat-producing region of the country (Tigray, Amhara, Oromia and SNNP) account for 99 percent of the country's wheat production in 2016/2017while only Amhara and Oromia region account 59 percent and 29 percent, respectively.

In the Amhara region, the west Amhara region of Gonder and Gojam contributes to the lion share of wheat production. Particularly, the west Gojam zone in which the study area is located produces wheat. It is estimated that 30,728 hectare of land is suitable for wheat production in the zone (CSA, 2015). According to YDARoD (2018/19), the total yield of wheat during three consecutive harvesting seasons of 2016, 2017 and 2018 was 9658.52 quintal, 10391 quintals and 12949.65quintal, respectively. This improvement in the yield of wheat in the district is due to extensive production. Farmers use more land to grow wheat through an expansion of wheat area but this practice is not advisable since land expansion is difficult and it is not a good way of boosting agricultural yield over food unsecured countries with high population pressure.

In nutshell, Even though the present government has given high priority to agricultural sector its productivity is at its lowest level due to different interrelated socio-economic and climatic problem such as inappropriate use of farmland, overgrazing, over-cultivation, population growth, weak extension service, inadequacy of infrastructure, low access to fertilizer and pesticides (Deressa, 2007). Also, Gebre (2004) explains that smallholder farmers are less productive due to they have low access to improved technology, financial service, modern inputs, agricultural market, and irrigation service which attributes variability of earning from the agricultural sector (Rahman, 2007).

With regards to the productivity of wheat production, 24-quintal per hectare in Ethiopia is considered as the national average yield of wheat which is triple times larger than that of 8 quintals per hectare in the 1990s production year since some improvements in technology adoption (CSA, 2014). But in China, the average yield of wheat is about 40 to 60 quintals per hectare whereas it is 60 to 80 quintals per hectare in Western Europe. This shows that productivity differences across countries in terms of wheat production and productivity.

In Ethiopia, though the greater part of the labor force employed in the agricultural sector, food insecurity is very high. For example, the Ethiopian demographic and health survey (EDHS) shows that children with stunting growth were around 44.4 percent, underweight children were 28.7 percent and children's wasting was 9.7 Percent. The survey also shows that the level of chronic malnutrition among women in Ethiopia was very high, with 27percent of women either thin or undernourished (EDHS, 2011). Besides, the United Nation Development Program (UNDP) report indicates that the human development index (HDI) of Ethiopian was very low and it is ranked 174 out of 188 countries in 2015 (HDR, 2016).

To address this food insecurity challenge the role of the agricultural sector could be high by increasing productivity and efficiency of farmers. Increasing productivity of the agricultural sector in general and crop subsector, in particular, enhance the income of rural households and food security. According to FAO (2015), the efficient use of resources in agricultural production is a precondition for attaining food insecurity and poverty reduction in an agrarian society. This is because efficient resource use enhances the productivity of inputs, in turn, it results in an optimal level of output from various combination of inputs. In other words, the productivity of farmers can be raised by either adoption of improved agricultural technologies or improvement in the efficiency of farmers or both. However, with the low rate of adoption of improved agricultural technologies by farmers, improving efficiency is the best option for productivity enhancement in the short-run (Mohammed and Kidanemariam, 2014).

In Ethiopia, there is a considerable agreement with the notion that an effective economic development strategy depends critically on promoting productivity and output growth in the agricultural sector, particularly among smallholder farmers. This can be achieved not only by generating and introducing high yield varieties of crops but also by considering the production efficiencies concerning scarce resources. Efficiency is a very important factor in productivity growth, especially for the developing agricultural economies where resources are meager and opportunities for developing and adopting better technologies are dwindling. This economy can be benefited greatly by deciding the extent to which it is possible to raise productivity or increase efficiency, at the existing resource base or technology (Wudineh, 2003). For efficient production, non-physical inputs, such as experience, information and supervision may influence the ability of a farmer to use available technology efficiently.

1.2 Statement of the Problem

Promoting productivity and efficiency of the agricultural sector could potentially help for poverty alleviation and food security improvement. Yet, the productivity growth of the sector is very low because of the absence of agricultural technology (limited access in terms of quality and quantity to improved seed and fertilizer, and pesticide) and the high price of these technologies. Furthermore, lack of knowledge on the efficient utilization of available limited resource and poor application of agricultural technology, land degradation, poor and biased agricultural policies, lack of transportation and storage facilities and poor market linkages also attributes to the low level of the sector (Jolejoleetal., 2012).

Ethiopia is one of the least developing countries where wheat is cultivated as a staple food crop. Wheat is produced as the source of consumption and income for consumers and producers, respectively. That14 percent of the total caloric intake of Ethiopia is enriched with wheat and its products (Nicholas et al., 2015). It is a preferred food and income a raising, the demand for wheat has grown significantly over the past decade and is expected to continue. Ethiopian's current annual wheat production of approximately 3.8 million tons is insufficient to meet domestic needs, forcing the country to import 30 to 50 percent of the annual wheat grain required. Unless productivity and production of wheat assured, the cost of wheat imports will place an increasing burden on the Ethiopian balance of trade. Since the importance of the crop and its growing import burden, the government of Ethiopia gives a high priority to promote wheat productivity and improves wheat marketing efficiency (Nicholas et al., 2015).

According to the EEA (2017) report, the national average yield of wheat is improved from 21.1 percent in 2013 to 26.8 percent in 2017 in a given hectare of cultivated land. Though wheat Productivity is increased from 18.39 to 2.1 tons per hectare in the 2010/2011 and 2012/2013 cropping season, its productivity is still very low (Wudineh and Endrias, 2015). Hence, it requires an effort to improve the productive capacity of the farmers to enhance productivity of wheat production by introducing new technologies, like fertilizer, improved seed and pesticides.

Empirical studies (Wudineh and Endrias, 2015, Wassie, 2012, Fekadu and Bezabih, 2008 and Solomon, 2014) done in a different part of the country prevail as there is potential to increase productivity or efficiency of wheat. A study conducted by Wassie (2012) in some parts of the

Amhara region shows that the average technical inefficiency for small scale seed producer farmers was 20.1perecent. The average technical efficiency of smallholder wheat farmers in the Welmera district was 57 percent (Wudineh and Endrias, 2015) while the mean level of efficiency of wheat production in Machakel woreda found to be 72 percent (Fekadu and Bezabih, 2008). Another study conducted by Solomon (2014) on analysis of technical efficiency of major crops shows that the average level of technical efficiency of major crops, teff, wheat and maize production was 63.57, 67.26, 84.16 and 91.41 percent, respectively. The studies indicate the existence of efficiency differential among farmers. This is a common thing that is prevailing among smallholder farmers, which may be true in the study area.

In the study area, wheat productivity declines from 26.1to 23.2qt/hectare between 2015 and 2017 (YDARoD, 2019). Thus, there is a need to give attention to this particular crop to improve its productivity. Analyzing the efficiency of farmers and the factor that affecting it may be one of the ways that help to improve the performance of wheat production in the district.

However, as to the researcher's knowledge concerned, there has never been scholarly known studies conducted on technical efficiency of wheat production in the study area and to identify the determinant of the variability of the efficiency level among farmers, the present study attempts to analyze the technical efficiency of farmers in the study area and intended to bridge the prevailed information gap on the contextual factors contributing to efficiency differentials among farmers in the production of wheat.

1.3 Research Question

- ✓ What is the level of technical efficiency of wheat production in the study area?
- ✓ What are the major socio economic determinants of technical efficiency of wheat production in the study area?

1.4 Objective of the Study

1.4.1 General Objective

The general objective of the study is to estimate technical efficiency of wheat production in the Yilmana Densa district.

1.4.2 Specific Objectives

Specific objectives of the study are:

- ✓ To estimate the level of technical efficiency of wheat-producing farmers in the Yilmana Densa district
- ✓ To identify the major socio-economic factor that affects technical efficiency production of wheat in the study area

1.5 Hypothesis of the Study

Based on researches reviewed, the hypothesis of the research of the study is formulated as; Wheat producer farmers in the study area are technically efficient and no production loss attached to wheat producer farmers.

1.6 Significance of the Study

There were no scholarly known researches conducted on the technical efficiency of wheat production in Yilmana Desna district so far. Therefore, this study has many contributions. Firstly, identifying factor that affects the technical efficiency of wheat crop help agricultural extension workers, farmers, researchers and policymakers by providing information to increase productivity and efficiency of wheat production. Especially, policymakers need to formulate appropriate policies regarding how to improve the technical efficiency of wheat production in the study area. Secondly, it widens the understanding of the determinant of technical efficiency of wheat crops. Finally, the paper serves as a reference for further research conducting similar topics and related issues.

1.7 Scope and Limitation of the Study

This study was conducted in Yilmana Densa district, West Gojam, by using cross-sectional data collected in 2019 G.C. The potential challenges faced in this study are a shortage of enough money, time and willingness of respondents to give appropriate information about the magnitude of the yield of wheat and relevant independent variables.

1.8 Organization of the Research

The study is organized into five chapters. The first chapter comprises the introduction part. It includes the introduction of the study, statement of the problem, objectives of the study, the research question and significance of the study. The second chapter deals with literature reviews on the concept of technical efficiency, various methodological issues concerning efficiency measurement and its source of differences in technical efficiency of wheat production. The third chapter deals with the research methodology. The fourth chapter contains results and discussion while the final chapter presents conclusion and policy implication.

2. REVIEW OF THEORETICAL AND EMPIRICAL LITERATURE

2.1. Review of Theoretical Literature

2.1.1 Concept of Production and Efficiency

2.1.1.1 Concept of Production

A production function is a relationship between inputs and outputs of a production process. In microeconomic theory, the production function is expressed as a technical relationship between the alternative combination of inputs used for production (land, labor, and capital) during a specified period and the maximum possible output produced, given the state of technical knowledge. Hazarika and Subramanian (1999) also describe production function as a maximum possible output for any given set of inputs setting a limit or frontier on the observed value of the dependent variable in the sense that no value of output is expected to lie above the production function. They added that the production process might be inefficient in two ways. It can be technically inefficient in the sense that it fails to produce maximum output from a given input bundle (due to overutilization of all inputs).

Moreover, Thomas and Maurice (2013) defined production as the transformation of raw materials into outputs. The raw materials refer to the input which combines each other to produce output. On the other hand, the outputs are the final product obtained from the combination of the raw materials. The production function or frontier shows the maximum attainable output from each input used. Thus, it is an indicator of the level of technology used in agriculture (Coelli and Battese, 2005). A particular production function can be expressed mathematically as:

$$f(xi, yi) = \max\{(yi: T(\mathrm{xi}, yi)\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (1)$$

Where yi represents the potential level of output (production frontier, xi is the number of different inputs used and$((\mathrm{xi}, yi))$ is the technological relationship between inputs and outputs. The traditional least square regression technique assumes all the variation from the frontier entirely due to statistical noise. However, producers don’t always produce at optimum level of production. Therefore, it is better to shift the analysis of production away from the traditional production function to the frontier production function (Kumbhakar and Lovell, 2000).

There are three basic assumptions to be made on the production frontier, given the existing inputs. The first assumption assumes that the production possibility on the frontier is attainable and efficient. The second assumption justifies that the production possibility below the frontier is attainable but technically inefficient. Finally, the third assumption is extreme in that the possibility of production is out of the potential of the entity (producer); therefore, the assumption is that the production possibility above the frontier is unattainable. Hence, production function describes production performance which can be measured by productivity and efficiency.

2.1.1.2 Concept of Efficiency

Efficiency analysis becomes the core issue of evaluating production performance since the works of Farrell (1957). Efficiency is a situation of society getting the maximum benefit from its resources. In the neoclassical theory of production economics and economic policy, measurement of productive efficiency has important implication which helps to test hypotheses regarding source of efficiency or differentials in productivity (Rios et al., 2005).

According to Coelli et al., (2005) and Coelli (1995), productivity and efficiency are different indicators used to measure the performance of a firm. For many scholars efficiency and productivity seems to be similar and both are a measure of the performance of a firm. However, these two interrelated terms are not precisely the same (Coelli et al, 2005).

In simple terms, productivity is the quantity of a given output of a firm per unit of inputs. The measure of productivity involves either total factor productivity, which is a productivity measure involving all factors of production or other traditional measures of productivity such as labor productivity in a factory and land productivity (yield) in farming which are often called partial measures of productivity. These partial productivity measures can provide a misleading indication of overall productivity when considered in isolation (Coelli et al, 2005). On the other hand, efficiency has a comparative concept and it is measured by comparing the ratio of actual output to inputs with the ratio of potential output to inputs which is represented by production frontier. Yield per hectare is the simplest way of measuring efficiency since it considers a single input of production, land. Conventional econometric analysis is the other technique that assumes that all producers always manage to optimize their production process. Even if the enterprises have the same technological and other constraints there are discrepancies between the production amount of output and production values of output. This may be depending upon different productive capabilities of farm agents and less favorable resource utilization by some enterprises (Burhan etal., 2009). Besides, efficiency is the highest productive level from each input level (Coelli et al., 1998). Hence, this shows that productivity and efficiency are not the same terms. According to Farrell (1957), there are three types of efficiencies. These are Technical efficiency (TE), allocative (AE) and economic efficiency (EE). Technical (physical) efficiency is the ability to minimize input use in production (Kumbhakar and Lovell, 2004). On the other hand, allocative (price) efficiency measures the ability of farmers to use inputs in an optimal proportion, given the price of inputs and output. Economic efficiency (overall efficiency) is the sum of technical and allocative efficiency (Coelli et al., 1998). Thus, they also said that farmers to be economically efficient, it must be both technically and allocative efficient.

2.1.1.3.1 Concept of Technical Efficiency

It is a very useful concept to utilize, when firms may be maximizing profits or output subject to profit constraints, as well as when optimizing other goals such as employment. The concept of technical efficiency related to the use of the best attainable technology in the production process (Chavas and Cox, 1988). According to Koopmans (1951), technical efficiency can be described as a situation where it is obstinate, with current technical knowledge, to raise output from given inputs or to produce a given output by using less of one input without using more of another input. Technical efficiency is a necessary condition, however not a sufficient condition for profit maximization, and a necessary condition for most of the constrained output maximizations. Therefore, it can be applied within a country to the analysis firms that have different objectives (Brada et al., 1997). Technical efficiency focuses on getting the maximum possible amount of output from a given level set of inputs; it is a precondition for economic efficiency.

In economic terms, technical inefficiency refers to failure operate on production frontier and generally is assumed to reflect inefficiencies caused by the timing and method of application of production inputs (Byerlee, 1987). As Scarborough and Kydd (1992) describe technical inefficiency also arise because of excessive input usage, which prevents cost minimization and profit maximization. In general, it arises when actual or observed output from a given input mix is less than the maximum possible and it can stem from a variety of sources, including lack of knowledge of available techniques or inadequate management due to lack of motivation, skills.

2.1.2 Approach of measuring Efficiency

There are two main ways of measuring efficiency; these are input-oriented and output-oriented approach. The input-oriented approach deals with how a firm can reduce its input without changing the level of output to be produced whereas the output-oriented approach deals with how a firm can expand its output from a given level of outputs. If the technology used in production exhibits constant returns to scale, then these two approaches of measuring efficiency will overlap with each other but they are likely to vary otherwise (Coelli et al., 2005).

2.1.2.1 Input Oriented Measurement of Efficiency

The input-oriented approach answers the question of how much the input use can be reduced without affecting the level of output. This approach focuses the amount by which all inputs could be proportionately reduced to achieve an efficient level of production

Farrell (1957) explained 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), under the assumption of constant returns to scale, where the assumption of constant return to scale will help us to present all necessary information on a simple isoquant.

2.1.2.2 Output Oriented Measure of Efficiency

Output oriented measure of efficiency answers the question by how much output can be increased without increasing the number of inputs used (Coelli et al., 2005). This approach is based on the assumption that inputs keeping constant, knowledge of fully efficient production possibility frontier and the iso-revenue line curve make it possible to measure and interpret economic efficiency. In the output-oriented measure of efficiency, the production consists of two outputs (Y_1,Y_2) with constant inputs (say labor L) and if the quantity of inputs fixed at a certain level the technology represented by production possibility frontier (Farrell, 1957).

2.1.3 Models of measurement of Efficiency

Measuring technical efficiency is concerned only with inputs and outputs quantity without the price of inputs and outputs. The current history of the measurement of efficiency was begun by Farell (1957) to which the origin of the present estimation method. But over time the estimation of the production frontier has tended to follow two general paths. The first one is the full frontier which assumes that all observation along the frontier and the variation from the frontier is considered to be inefficient. The second path is the stochastic frontier estimation where the deviation from the frontier is considered to be a random component resulted from measurement error, statistical errors and inefficient component (Okoruwa and Ogundele, 2006). The estimation of the full frontier can be investigated either using a parametric approach where the estimation is done by using statistical techniques or a non-parametric approach where the estimation is conducted by using linear programming for each firm.

Two analytical models can be used to measure efficiency in production. These are parametric frontier models and non-parametric frontier models. A parametric approach is represented by a deterministic and stochastic frontier approach while for non-parametric model Data Envelopment Analysis (DEA).

2.1.3.1 Non-Parametric Frontier Model

The most known non-parametric frontier approach in productive efficiency analysis is DEA which was initially developed by Charnes et al., (1978). The non-parametric frontier model is based upon Farrell's original approach of convex isoquant such that no observed points lay to the left or below it. It is non-parametric, as it does not require an explicit functional form and constructs the frontier from the observed input-output ratios by linear programming techniques.

The main advantage of DEA is that it is flexible and can accommodate multiple inputs and outputs with different units and used to examine the efficiency of groups of decision-making units (firms, producers and farmers). This model also doesn't involve the assumption of functional form in relating inputs and outputs (Coelli et al., 1998). The most serious drawback of DEA is that it assumes all deviation from the frontier is due to inefficiency. Besides, it ignores statistical procedure for hypothesis testing (Coelli., 1995) and it doesn't put a prior parametric restriction on underlying frontier technology. Thus, DEA is both a non-stochastic and non-parametric frontier model.

2.1.3.2 Parametric Frontier Model

The parametric approach depends on the assumptions about the mathematical form of a production function. Hence, the conventional assumption of neoclassical production theory about the shape of the production frontier is maintained in the parametric method. Parametric models are two types' these are deterministic and stochastic frontier models and both of them use the econometric techniques to estimate the parameters of pre-specified functional form.

The non-stochastic or deterministic parametric method was initially estimated by Aigner and Chu in 1968 cited in Coelli et al., (2005), who estimated Cobb- Douglass production frontier using quadratic and linear programming. This approach does not take into account the possible influence of measurement error and other and other noises upon the shape and position of the estimated frontier (Coelli, 1995). Alternatively, any deviation from the frontier considered being inefficiency. The deterministic parametric approach can be estimated by linear programming and other econometric technics such as Corrected Least Square (COLS). The method has an application, especially, in the case where there is a high probability measure of risk, will exaggerate the inefficiency estimates as compared to stochastic parametric or non-deterministic approach.

The concept of plotting inputs per-unit of output observations as points in a space of suitable dimension by Farell (1957) had not been widely used until the introduction of the stochastic frontier production function, independently proposed by Meeusen and Vanden Broeck (1977) and Aigner et al., (1977). Unlike the non-parametric approach, the stochastic frontier approach assumes deviation from the frontier as stochastic noise and measurement error. According to Neff et al., (1994), the ability of a stochastic frontier to incorporate random disturbance term to account for events beyond management control is appealing, the need to use the estimate to measure inefficiency may provide very similar farm efficiency estimates. The stochastic parametric method has many advantages than DEA in agricultural production especially in developing countries because the collected data influenced by measurement error and effect of environmental changes. Besides, the ability to have lower variability than other methods due to error decomposition is one of the merits of a stochastic parametric method (Neff et al, 1994). According to Farrell (1957), both deterministic and DEA don't incorporate measurement error and random shock and they are sensitive to an outlier. But the stochastic parametric method assumes these shocks and uncertainty, involve both random error and inefficiency component. The other importance of stochastic parametric method over deterministic parametric method is that estimation of standard error and test of hypothesis is possible, which the latter fail to fulfill because of violation of maximum likelihood regularity condition (Coelli, 1995). The stochastic parametric method can be estimated by maximum likelihood or COLS. Unless for its simplicity of COLS, it is recommended to use maximum likelihood because the maximum likelihood is asymptotically efficient (Coelli et al., 1998).

On the other hand, the major drawback of this method as compared to the non-parametric approach is its inability to construct different frontiers for every observation (Neff, et al, 1994, Ogundele and Okoruwa, 2006). However, it was overcomed by measuring the mean of the conditional distribution of inefficiency (ui) given the random error (εi) (Jondrow et al., 1982). Coelli et al., (2005) justify the strong limitation of stochastic parametric method such as imposition of functional form and no prior justification for the selection of a particular distributional form for the one side inefficiency term, inability to incorporate multiple outputs assumes separately the one-sided error term from the physical inputs that are not realistic.

2.2 Review of Empirical Evidence

2.2.1 Review of Empirical Evidence from other Countries

By using Stochastic frontier analysis for rice production in Bangladesh Rahman S. and Rahman M. (2009) indicated that land fragmentation decreases efficiency and resource ownership including land, draft animal and adoption of new technology and family labor increase efficiency of farmers. For Vietnam, Huynuh and Mitsuyasu (2011) estimate the technical efficiency of rice production using farm household living standard survey of 2005/2006. Their result shows that the mean technical efficiency of rice producers was found to be 81.6 percent. According to their result intensive labor in rice production; irrigation and education have a positive impact on the technical efficiency of rice production.

Thingan (2013) found that farm size is positive and statistically significant at 1 percent level of significance, the larger farm size the greater technical efficiency. The study implies that the relation between farm size and technical efficiency in Vietnam violates the inverse relationship theory. Land fragmentation and education influence technical efficiency negatively and land-use intensity is not determinate of technical efficiency. According to Abba (2012), the mean technical efficiency of sorghum producers was 76.62 percent. He used a stochastic frontier production function and used the data collected from a sample of 100 sorghum farmers in Adamawa state. His result revealed that the major factors that influence sorghum output were land, seed and fertilizer. According to his result education, extension contact and household size were the major explanatory variables that have a significant effect on the technical efficiency of sorghum producers. From his result, the smallest technical efficiency of farmers was 15.62 percent and the largest was 92.14 percent. In his study, the level of technical inefficiency was around 27 percent implies that there is an opportunity to increase sorghum output by 27percent using the existing resource and current level of technology efficiently. Finally, he recommended policy intervention by the government in terms of better access to land, fertilizer and improved seed.

Mwajombe et al.,(2015) employ a stochastic production frontier to estimate farm level technical efficiency of urban agriculture inTanzaniaTawon. Farm-level data of 270 urban agriculture farmers were collected through semi-structured questioner in the study area. The study found that land sizes, total variable cost and extension service influenced technical efficiency negatively. The smaller land size for Urban agriculture imposed production efficiency, especially for urban agriculture practices requiring larger areas like dairy cattle keeping. However, an urban agricultural activity like poultry keeping conducted on smaller land size. Ouedraogo (2015) conducted a study on economic efficiency on the irrigated land of Bagre in Burkina Faso applying a stochastic production frontier. He had the objective of assessing the potentials for increased rice production and identifying the determinants of efficiency that needed to be boosted. The results indicated that there is a potential to be exploited if farmers efficiently combine inputs. Factors like mineral fertilizer, improved seed and capital were identified to improve economic efficiency if properly used by rice farmers.

On the other hand, Aboki et al.,(2013) employ a stochastic frontier production function model and cost to analyze technical, allocative and economic efficiencies of Cassava production inTarbastate, Nigeria. He found that farm size, family labor, fertilizer, household size, year of schooling and source of funds were significant and have a positive influence on cassava output. The study of Shakilasalam and Siegfried (2014/2015) indicated that numbers of active household members, age, farm size, and ownership of agricultural machines are important factors for reducing the inefficiency level of part-time agricultural households. They employed the Cobb-Douglas production function through the stochastic frontier model using a sample of 153 households to examine the effect of non-farm income employment on the technical efficiency of a rural farm household in Bangladesh. In the study family, laborers are found to be more efficient than hired laborers in non-farm based agricultural households. Moreover, the significant effect of labor indicates the labor-intensive farming system in Bangladesh, though small-scale mechanization is now used. It is mainly used for specific field activities.

Kalirajan and Shand (1988) apply both COLS and maximum likelihood estimation techniques in measuring the level and causes of technical efficiency of farmers in southern India, Ramnad, both at the farm level and at crop level. They analyzed the sources of technical efficiency differentials using multiple regression analyses for each crop independently. It expected that farming experience; extension visit, credit availability, and education level of the household head are the potential sources. The result indicates the technical efficiency gap differed between crops under investigation. For example, for rice crop production, farming experience and extension visit was found to affect the efficiency whereas, for corn production, financial availability was the most determining factor. Their analysis concluded that a mere choice of high yielding technology is not sufficient to increase rice crop production; rather the proper use of these technologies is vital. Research conducted by Hanan et al.,(2017) using slack based data envelopment analysis and fractional regression model to analyze the technical efficiency of a traditional wheat farmer in the Fezzan region in Libya. Five variables such as experience, age, education, farm size and main occupation were found to have a significant effect on technical inefficiency. Years of farming experience are negative and statistically significant at 1 percent level significance indicating that farmers with more experience tend to be more efficient than with less experience. Moreover, the study indicates that the age of the household affects technical inefficiency positively. Old farmers are more technically inefficient than young farmers. Farm size influenced technical efficiency negatively; the bigger the size of the farm, the lesser its inefficiency.

In the Chinese agricultural sector Adam et al., (2003) by using a stochastic production frontier approach indicate that technical efficiency is affected by land, labor, fertilizer and capital. They found that households usually use more than 80 percent of their land in grain production. The use of chemical fertilizer in most cereal crop production is the most important inputs as explained by different researchers.

A research done by Manjeet et al.,(2010) on technical efficiency of wheat production in Punjab: regional analysis observed that chemical fertilizer as nutrients was highest in the central region

(340 kg/hectare), followed by south-western region (220 kg/hectare) and the lowest for the semi-hilly region (102 kg/hectare).

Sarfraz et al.,(2005) apply stochastic production function to estimate the technical efficiency of wheat farmers in a mixed farming system in Punjab, Pakistan. J.flinn (1989) use an OLS regression to estimate profit efficiency in Basmati rice farmers in Pakistan. According to their result, there was inefficiency which is between 5-87 percent and farm efficiency was affected by socio-economic factors like non-farm employment, household education, credit constraint and institutional constraint. Late delivery of fertilizer was an institutional constraint that leads to late planting in turn impact on technical efficiency of farmers. They used a stochastic frontier approach for their efficiency analysis which can account for random and farm-specific errors.

Amaza and Iheanacho (2013) examine the technical efficiency of the output of food crops in the Borno state of Nigeria by using data collected from 1086 sample farmers in the 2004 cropping season. According to their result factors such as fertilizer, hired labor and farm size were the major factors that determine the output of food crops. They found that fertilizer, land area and hired labor have a positive effect on the output of food crops. They also found that credit, extension contact, age, education and crop diversification are farm-specific factors that account for the observed variation in efficiency among farmers. Chukwuji et al (2006) use stochastic production function to estimate the technical efficiency of Gari processing in Delta state, Nigeria. According to the analysis of the study, there was a wide variation in the level of technical efficiency in Gari processing, a minimum of 25 percent and a maximum of 88 percent, with a mean efficiency level of 65 percent. The result of the analysis revealed that the technical efficiency of processors is determined by socioeconomic factors such as level of formal education, family size, age, credit, membership of Gari processing association and alternative source of income.

2.2.2 Review of Empirical Evidence in the Ethiopian Context

Gideon et al., (2010) studies resource use efficiency of smallholder wheat producers in the central highlands of Ethiopia. Their objective was to examine the resource use efficiency of smallholder wheat producers using a random household survey of 700 households. In their analysis, they apply a two limit Tobit regression model and their result reveals that inefficiency in resource use is positively affected by family size, membership and experience. Their result suggests that resource use efficiency and productivity are significantly improved through expansions of no farm sectors and reform of farmer related associations. Solomon (2014) studied to measure the level of technical, allocative and economic efficiency of wheat seed production and to identify factors affecting them in the study area. The study was conducted using cross-sectional data collected from 150 sample households from Womberma Woreda of West Gojjam Zone. The stochastic production frontier model was used to estimate technical, allocative and economic efficiency levels, whereas the Tobit model is used to identify factors affecting efficiency levels. The result indicated that there was significant inefficiency in wheat seed production in the study area. Accordingly, the mean of technical, allocative and economic efficiency of sample households was 79.9, 47.7 and 37.3 percent, respectively. Results of the Tobit model reveals that interest in the wheat seed business and total income positively and significantly affect technical efficiency while total expenditure had a negative and significant effect. Education level and livestock ownership had a significant positive effect on allocative and economic efficiency while land ownership and total cultivated land had a significant negative effect on allocative and economic efficiency, respectively.

Kinde (2005) estimates the stochastic frontier model (trans-log functional form) for maize production in the Assosa region. The test result showed that there is technical inefficiency in the production of maize in the study area and the relative deviation from frontier due to inefficiency is 96 percent. The estimation of the frontier model with inefficiency variables indicates that the technical efficiency of farmers in maize production is 67 percent. This implies that farmers do not efficiently utilize production inputs in such a way that they provide maximum potential. The researcher found that off/non-farm activities, land fragmentation, educational status of the family members, age, and credit availability positively affect the technical efficiency of farmers.

Wassie (2012) study the technical efficiency of small-scale wheat seed producer farmers in Ethiopia. According to his findings, the mean technical efficiency of the sampled household was 79.9 percent. He used the Cobb-Douglas production function to find the elasticity of inputs and the level of efficiency of each producer. He used Tobit model to determine factors that affect the efficiency of farmers. His result also shows that total income and interest in wheat seed business positively and significantly affect the technical efficiency of wheat seed producers of farmers. But technical efficiency of wheat seed producers of farmers was negatively and significantly affected by total expenditure.

Awoke (2011) applied a stochastic frontier to estimate the technical efficiency of smallholder cereal crop producers in the Amhara region. His result showed that the traditional production function cannot represent the data, which implies that there is a difference between the traditional production and frontier production due to the presence of inefficiency. Wudineh and Endrias (2015) noticed that sex, age and education of the household head, distance to all-weather roads, credit service, and group membership, extension contact, training, land fragmentation, tenure status and investment on fertilizers significantly influence technical efficiency. They use translog production function to determine the level of technical efficiency of smallholder barely farmer: the case of Welmera district. In their study, they found that technical efficiency ranges from11 percent to 99 percent with an average of 53 percent.

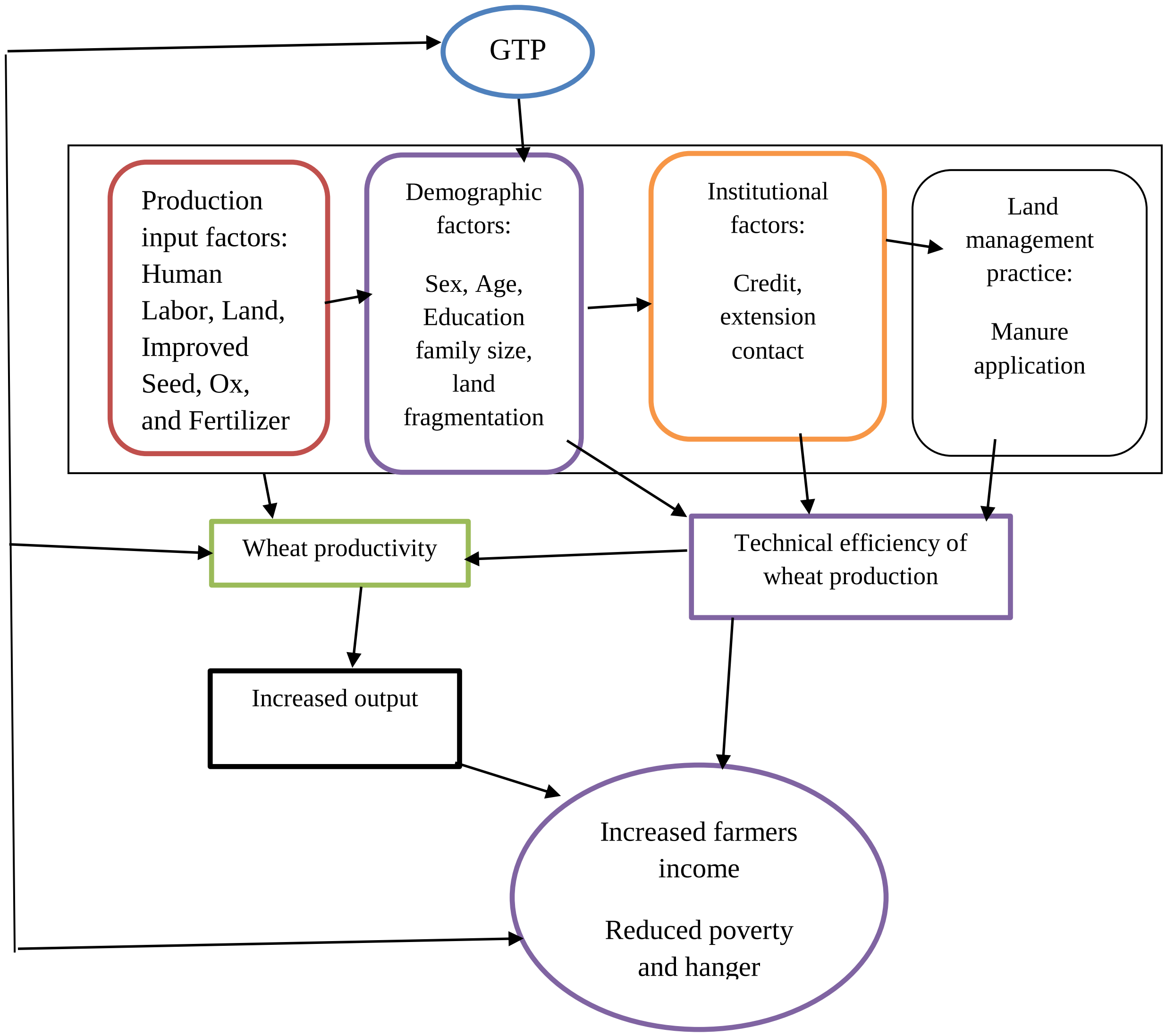
A study conducted by Wollie (2018) on the technical efficiency of Barley production of a smallholder farmer in Meket district reveals that input variables like fertilizers, human labor, proximity and oxen power were significant; however, barley seed had a negative effect on barley output. The result of the study indicates that the mean technical efficiency of the sample farmer is 70.9 percent which implies Barley output must increase by 29.1 percent. Gemechu (2014) in his study of off-farm income and technical efficiency of smallholder farmers in Ethiopia, showed a size of farmland, household size, off-income, gender and education of the household head are the most significant variables determining the value of farm output to other types of non-farm activities self-employment increases the farm technical efficiency. Abay and Assefa (1996) analyze the impact of education on the allocative and technical efficiency of smallholder farmers in Ethiopia. By using profit function and various linear restriction and wald test, they conclude that educated farmers are technically and allocatively more efficient than illiterate farmers. Besides, they found that the mean profit inefficiency of farmers was 46 percent, which is large compared to the average inefficiency level of many studies.

Shumet (2012) estimates the technical efficiency of crop production in the Tigray region, the mean technical efficiency of farmers is 60.38 percent. His finding shows that except labor all factor inputs have a positive and significant effect on crop production. The estimated stochastic frontier production function revealed that all determinants except household's sex, farm size participation in irrigation, and member to the association have a significant effect on the efficiency of smallholding farmers. Abrar (1995) conducted a study on measuring the technical efficiency of a fertilized farm by employing a stochastic frontier model, across-sectional analysis from three villages of Ethiopia. He analyzed that expanding output of the average farmers up to 40 percent was possible if appropriate measures were employed to improve internal efficiencies. His result states two basic conclusions. Firstly, the traditional Cobb- Douglass production function is not suitable to explain the production behavior of farms. That means technical inefficiency is one of the main characteristics of agricultural production for farmers under the study. Secondly, technical inefficiency does not only vary between villages but also there is a high difference among farmers within one village. Sakita (2010) found that Family size, education and livestock were the significant determinants of technical, allocative and economic efficiencies of haricot beans production in Adama and Dugda districts of East Shewa Zone. Also, the researcher reported that land fragmentation has a significant impact only on technical efficiency, while credit service has a significant effect on allocative efficiency. Extension visit was an important factor in determining both technical and allocative efficiencies.

2.3 Conceptual Framework

The author provided a conceptual framework for the study. The conceptual framework shows how briefly socioeconomic characteristics of the farmers, institutional factors and national policies are interrelated to reduce poverty. For instance, the Growth and transformation plan (GTP) has been implemented to influence the socioeconomic characteristics of farmers, institutional services to be provided for the farmers. Specifically, the agricultural sector targets of GTP aim to increase productivity and efficiency of farmers and hence reduce poverty and food insecurity.

Figure 2.1 : Conceptual framework based on literature



3 METHODOLOGY

3.1 Description of the Study Area

Yilmana Densa district is one of the districts in the West Gojam zone of the Amhara Region. Adet is the center of the district. Relatively, it is bordered on the south by Kuarit, on the southwest by Sekela, on the west by Mecha, on the north by Bahir Dar Zuria, on the east by the Abay River which separates it from the south Gondar Zone, and on the southeast by the east Gojam Zone. The absolute location of the district indicates that it is found between11.27º latitude north and 37.48ºlongitude east. The district is categorized into 30 rural kebeles[1] and 5 urban kebeles with a total population of 508445 of which 252962 males and 255483are females (CSA, 2013). The height of the district ranges from 1600 to 3570 meters. It has75.65 percent Weyina Dega and 24.35 percent Dega agro-ecological zone.

The rainfall distribution in the study area is uni-modal and the rainy season lasts for four months from mid-May to mid-September. The average annual rainfall is 1,270 mm per annum. The total area of the district is about 99180 hectare of which 49359 hectares of land (49.78percent) is suitable for cultivation. Out of the total area of land, flat land accounts 16, mountain 20, valley 8 and highland 56 percent, respectively (YDARoD, 2019).

Agriculture which predominantly rain-fed is the main source of the livelihood for the majority of the people in the district. A mixed farming system (crop-livestock) is very common and has been practiced thought traditional farming methods. The major crops grown in the area are wheat, teff, faba bean, maize; chickpea field pea, barley and sorghum, noug [2](YDARoD, 2019).

3.2 Data Source and Method of Data Collection

The study used primary data from a cross section of 194 observations. Primary data contains detailed information on household socio-economic, demographic and farm characteristics, inputs utilization, output produced, institutional, policy-related variables and production problems encountered.

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[1] Kebele is the smallest administration unit in Ethiopia.

[2]. Noug refers to oil-bearing cereal crops produced in Ethiopia, especially in the study area.

To collect the data, a structured questionnaire was designed. The questionnaire was prepared in English and for the sake of understanding by enumerators and respondents; it was translated into Amharic. The questions were both open and closed-ended type. To keep the content, clarity, and logical flow of the questions and the time needed on average to fill out a single questionnaire, the translated version was corrected and finalized. Four selected enumerators who have completed grade10 and12 were recruited and trained to facilitate the task of data collection on wheat outputs and inputs.

3.3 Sampling Techniques and Sample Size

The study used multistage random sampling technique. First, Yilmana Densa district was purposively selected due to wheat is one of an important cereal food crops in the district. Second, out of 14 wheat-producing kebeles, 3 kebeles were purposively selected based on their potential for wheat production. Farm households have homogenous characteristics in farming practice, adoption of technologies and they have similar topography like agro-climate conditions in selected kebeles. Finally, 194 representative sample households were selected in proportion with sample frame in each selected kebeles through simple random sampling. A list of farm households obtained from the kebele administration and extension office. Hence, the minimum sample size is randomly selected based on proportional to size using the formula of Yamane (1967).

$$n = {}^{N}/_{1+N(e)^2}$$

Where “n” is the sample size, N' is the total number of farmers in the district and ‘e’ is level of precision. After the total sample size determined, the sample to be taken from each Kebele is allocated proportionally to the number of households living in the given Kebele. According to YDARoD (2019), the district has 13056 farmers which 3992 of them are in 3 kebeles and they are selected as a targeted population. Approximately, 194 representative sample farmers were selected at 95 percent confidence level and 0.07percent precision.

$n = \frac{3992}{1+3992(0.07)^2}$, n=194 farmers

Table 3. 1: Sample size taken from each selected kebele

No	Name of kebeles	Households size	Proportion	Sample size
1	Abiyot Firie	1527	38.3	74
2	Chenqulit	1454	36.4	70
3	Ayevar	1011	25.3	50
Total		3992	100	194

Source: Own computation based on YDARoD report, 2019

3.4 Methods of Data Analysis

The analysis involves both descriptive and Econometric methods. Descriptive statistics such as mean, percentage, range, standard deviation are used to summarize the variables used in the model. In Econometrics analysis, on the other hand, a stochastic frontier approach is employed. The stochastic frontier approach could account for measurement error and other Statistical noise influencing the shape and position of the production frontier. Moreover, this approach captures exogenous shocks that are beyond the control of farmers. Hence, the stochastic frontier approach is the best fit for agricultural production and efficiency which are highly influenced by external shocks like weather conditions. This technique is based on the assumption that farmers may deviate from the frontier not only because of measurement error, Statistical noise and any non-systematic influence but also because of technical inefficiency. Analogous to DEA, SPF analysis captures composite error terms (Statistical noise and inefficiency effect) in the specification and estimation of stochastic production function. In addition to the SPF model, the inefficiency model is used to identify the major determinant of farm-level technical inefficiency through the maximum likelihood estimation method. To estimate the stochastic frontier production function and the inefficiency model stata 12 computer program is used.

3.5 Model Specification

Stochastic production frontier model which was proposed by Coelli (1995) used to determine the efficiency of wheat production in the study area. Therefore the general SPF model containing composite error specified as:

$$Yi = f(Xi, \beta) \exp(Vi - Ui), i = (1,2 \ldots . N) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

Where Y_i measures the quantity of output of the ith firm in kg, X_i represents level of input j^{th} of the i^{th}- farmer, β_i is a vector of unknown parameters to be estimated, N is the number of sample farmers and f ( ) is a suitable functional form such as Cobb-Douglas production function or translog production function.V_i represents pure random error term which is independently and identically distributed as V_i ~N (0; σ^2), independent of Ui. It allows random variation of output due to factors outside of the control of farmers such as weather conditions, diseases, bad luck and measurement error in the output variable.

U_i is the inefficiency component error term and a non-negative (U_i >0) random variables associated with technical inefficiency relative to the stochastic frontier. It is independently and identically distributed as half normal, truncations at zero with mean μi and variance σu^2, U_i ~ N (μi, σu^2). The Cobb-Douglass of SPF is widely used in economics literature due to its simplicity and logarithm nature of production function which makes parametric estimation easier and helps to interpret elasticity coefficients. Many studies such as Wollie (2018), Abokietal,. (2013); Rahman S.and RahmanM. (2009), Adam et al.,(2003) and Sarfraz and Beshir (2005) are used Cobb-Douglass of SPF. Similarly, the researcher employed Cobb-Douglass of SPF to estimate the efficiency level of wheat production. Thus, the linear functional form of Cobb Douglas production function used in this study is given by:

$$lnYi = \beta o + \beta 1 lnx1 + \beta 2 lnx2 + \beta 3 lnx3 + +\beta 4 lnx4 + \beta 5 lnx5 + vi - u \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . (3)$$

Where Y_i is defined in equation 2 above. X_1= Amount of artificial fertilizer used in kg per hectare, X_2= Amount of improved seed used in kg per hectare ha, X_3=Number of oxen used, X_4= Number of labor used, X_5=Land use in hectare and ln is the natural logarithm

Next, based on technical efficiency score the technical inefficiency effect is specified by using the Tobit model as follow:

$$TI = \delta 0 + \delta 1Z1 + \delta 2Z2 + \delta 3Z3 + \delta 4Z4 + \delta 5Z5 + \delta 6Z6 + \delta 7Z7 + \delta 8Z8 + \delta 9Z9 + \delta 10Z10 + \delta 11Z11 + \delta 12Z12 + \delta 13Z13 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 4$$

Where, TI represents Technical inefficiency level, Z_1=sex, Z_2 =Age, Z_3= age square, Z_4= family size, Z_5 =extension contact, Z_6= illiterate, Z_7=primary education, Z_8= secondary education, Z_9 = credit amount, Z_{10}= land fragmentation, Z_{11}=membership, Z_{12}= proximity, and Z_{13}=Manure application. δi Represents coefficient of independent variables, Z indicates the i^{th} attribution of the j^{th} individual farmer.

3.6 Definition and Measurement of Variables

3.6.1 Output and Independent Variables

Both output and independent or input variables measured in the 2018/19 Meher production season are described in this section. To estimate the Cobb-Douglas production function both inputs and output variables were converted to their log values.

Output refers to the actual total amount of wheat yield produced during the 2018/2019 Meher production season. Output, which is a dependent variable in the estimation of production functions, is measured in quintal (Qt) per hectare. Therefore, wheat output measured in quintal used for this analysis.

On the other hand, independent Variables are production inputs which include all factor of production that is used either directly or indirectly in the production process. Specific to wheat production, input variables refer to variables that can be used to produce wheat grain. They are directly applied in the process of wheat production. These variables are also termed as efficiency variables this is because they are used directly in the SPF model during the estimating level of technical efficiency. The quantity of these variables used in the model determines the level of technical efficiency of wheat production. These are described as follows.

Land: Is the total area of cultivated land devoted to wheat production by the farm households. The land is the most important input in smallholder production. The land is measured in terms of a standard unit is called hectare.

Artificial Fertilizer (fert): Refers to the amount of inorganic/chemical fertilizer used during the process of wheat production. Unlike the old days, there is an increased demand and use of inorganic fertilizer in Ethiopia (Kefyalew E., 2011). Fertilizer is a continuous variable and it is measured in terms of an international unit is called kilogram (Kg).

Improved Seed (Imseed): The amount of improved wheat seed used in a kilogram. The source of improved seed for wheat producer most commonly are agricultural expert's seed supply. Therefore, the total amount of improved wheat seed is used for the analysis.

Labour (lab): Refers to the total number of labor (family and hired) employed in different farm activities like land preparation, ploughing, sowing, weeding, and harvesting.

Number of oxen (oxen): the total number of oxen used in various farm activities in wheat products such as ploughing, sowing, and harvesting. It is used in combination with human labor and measured in a number of heads of oxen used or oxen owned. In sum, many empirical studies have shown a positive association between inputs and output which indicates farmers with more inputs are expected to produce more output. Therefore, a positive relationship between output and input variables is expected.

3.6.2 Inefficiency Variables and Expected Sign

Inefficiency variables are variables which include socio-economic, biological and institutional factors that affect technical efficiency. Since inefficiency variables indicate why not farmers become technically efficient during the production process, they are commonly called efficiency factors. The dependent variable in the inefficiency effect model is the technical efficiency score, which is computed from the parametric method of efficiency measurement. These inefficiency variables are explained as follows.

Sex of the household head (sex): Refers to male or femaleness of the farm household. It is a dummy variable and takes value 1if the household head is male and 0, otherwise. Male headed household heads have more access to resources and information related to better production technologies than female-headed household heads due to their social position. Most often females don’t participate in an agricultural activity like ploughing because they engaged in a household domestic activity like child care.

The Age of household head (age) and age square: This is the age of the household which is considered as a proxy for farming experience, measured in years. An empirical study, for instance, Tan et al., (2010) argue that older households are more experienced to younger ones. In contrast, Kinde (2005) and Fekadu (2004) argue when farmers became more mature they become more efficient since they exposed to new methods and technology. But farmers would be less efficient as they become older and older due to their ability to operate in farm activity declines. Therefore, this study is aimed to identify which side of the variable is influential.

Education of HH head (Educ): this is the level of education of the household head. The educational level in this study includes illiterate, primary school education and secondary school education. Education can determine the ability to accept ideas and technological innovation and strengthen willingness to use recommended agricultural practice such as strep cropping, manure application, and other local and modern practice. Educated farmers could have better access to technology about price, and state of technology and its use. More educated farmers show a better tendency to adopt new agricultural technologies than less-educated farmers (Ram et al., 2011). The study conducted by Kinde (2005) and Fantu etal., (2015) argued that the level of education and technical efficiency have a positive relationship. Therefore, education of household head is expected to have a positive impact on technical efficiency.

Land fragmentation (Lfrag): It is a dummy variable that assumes 1 if households land is fragmented, 0 otherwise. Fragmented land is difficult for Farming. However, a farmer having fragmented land becomes more efficient than a farmer with no fragmented land. This because a farmer with fragmented land may be able to distribute labor resources for various plots at the same time. Tan et al., (2010) assured that land fragmentation increase technical efficiency. Hence, land fragmentation is expected to affect technical efficiency positively.

Extension contact (Extcontact): It shows the frequency of extension service that farmers receive from extension experts during the 2018/19 production period. It is the service that a farm household obtains an idea about agricultural practice, resource use, and other advice. Extension service improves human capital and the management skill of farmers to enhance their level of efficiency (Mathews et al., 2011). Farmers who have long contact are expected to be more efficient than their counterparts. Therefore, extension contact, which is a continuous variable measured in terms of a number of times visit. It is hypothesized to influence technical efficiency positively.

Manure application (manure): Represents the application of manure for wheat production. It includes the application of animal dug and plant materials for fertilizing the land particularly animal extra with litter. Hence, Sometimes, it is called compost and used in combination with inorganic fertilizer to increase rainfall use efficiency. Increased use of the amount of manure will have a positive effect on developing the production potential of rainfall resources and could improve soil-water conditions and increase rainfall efficiency at each growth period of the crop. Therefore, Manure application, which is a dummy variable takes1 if the household applies manure, 0 otherwise. For this study, A farmer who applies manure on its farm will be more efficient.

Amount Credit (amt credit): The total amount of credit farm households obtained from microfinance or other individuals to facilitate wheat production edition in the production season. Farmers in the developing country need credit than developed country farmers due to capital is insufficient under developing countries. Thus, credit can create a clear potential for a household to purchase new agricultural inputs at a time which might be impossible or take a long time if it was thought to be purchased by timely saving from one income. Kinde (2005) identified that the amount of credit and technical efficiency of crop production have a positive relationship. For this study also, the amount of credit is hypothesized to have a positive influence on technical efficiency.

Membership of Socio-Economic Organization (membership): This represents one of the local socio-economic organizations engaged by farmers to improve their livelihood. This social organization includes Idir, Ikub, debo, mahiber and cooperatives. The role of social capital in providing an incentive for efficient production is high. Information sharing on production at club or association tends to diffuse to other members of the household that are not a member. Thus, membership is a dummy variable such that 1if household is membership, 0 otherwise. For this thesis work, a farmer who is a member of the assoiciation expected to influence technical efficiency positively.

Family size (Fsize): This is a continuous variable stands for the total number of a family member in the household. Family is the most important source of labor used in the study area. Family size would have a positive effect on raising the efficiency effect in production wheat. Since labor is the main input in crop production as a farmer has a large family size he/she would manage crops on time. Therefore, family size is expected to relate positively with technical efficiency.

Proximity: This refers to a distance where the farmland away from house hold’s home. This inefficiency variable is a continuous variable measured in a minute. If the farmland is far from the farmer's residence it will take them more time, as a result, they will be less efficient. Hence, proximity influences technical efficiency negatively.

4 RESULTS AND DISCUSSION

4.1 Descriptive Analysis

Descriptive statistics of the essential variables is tabulated in table 4.1, 4.2 and 4.3. The tables introduce us the profile of respondents.

4.1.1 Household's Demographic Characteristics

The study revealed that the average age of household heads in the study area is 44.46 years. Young aged households are more likely to use better agricultural technologies like improved seed and quality fertilizer and land management practice. Kinde (2005) and Fekadu (2004) indicate that young farmers could adopt agricultural innovations more quickly and readily than older farmers since agricultural activity demands more effort.

Also, the study shows that the majority of the household heads are males (58.76 percent) while 41.24 percent are female household heads. Thus, male headed households perform more than female headed households since male headed households often have better control over the households resource and decisions concerning to adoption of agricultural inputs and technologies.

Family size is an important variable affecting the level of technical efficiency since family size affect the allocation of financial and human resources based on the number of a family member (Wudineh, 2013). The average family size in the study area is 4 persons per household with a minimum and maximum family size of 2 and 10 persons per household. High number of family members have accessibility of family labors for the achievement of agricultural activities.

The survey result indicates that the majority of the households are illiterate (41.75 percent) while the remaining households have a primary level of education (30.93percent) and secondary level of education (6.70 percent). Literate farmers have better opportunities for management skill and input use techniques gathering information quickly than illiterate farmers.

4.1.2 Plot level Characteristics

The study indicates that the majority of sample households (57.73 percent) have fragmented land while the remaining (42.27 percent) have no fragmented land. This implies that households would face wastage of labor and inputs as the number of plot size increase the timing of performing because managing on fragmented land is difficult. However, studies like Belaineh (2003) explained that farmers having more plots do not need more information. This is due to spatial diversification is one of risk management in space and time leading to a better livelihood.

In the study area, on average, the sample households spend 25.57 minutes to travel from its home to the farmland. Also, the minimum and maximum walking distance from residence to its farmland is 2 and 65 minutes with a standard deviation of 14.92 minutes. A farmer whose farm land is far from its residence will be less efficient than those farmers whose farmland is near to their home. This is because transportation of fertilizers and other inputs to the farmland would be difficult.

Besides, the study reflects that among 194 sample respondents, 71.65 percent sample households use manure application while the remaining 28.35 percent sample households don't use manure application. Manure use has a positive effect of increasing production potential of rainfall resource, can improve soil water condition and increase rainfall use efficiency at each growth period of the crop to obtain the goal of utilization of rainfall resource.

4.1.3 Institutional Characteristics

It is assumed that farmers who have access to credit will have an opportunity to get farm inputs timely and help them to increase wheat production and productivity in general and it is the most important variable in resource-poor farmers in particular. The average amount of credit that farmers obtain is 7771.046 birr ranging 100 birr to 68278 birr. About 40 percent of the household get credit from ACSI (Amhara Credit and Saving Institution), 25 percent from relatives and friends, 15 percent from money lender and 20 percent from others source. Households use credit for different activities like for the purchase of farm inputs, for school expenses for their family, for making houses for a living and other conditional activity.

The average number of extension contact made by extension experts with wheat farmers for crop related information is 1 ranging from 0 to 5. The concept of agricultural growth inform us that extension service affects agriculture in two ways. First by facilitating the dissemination of new technology to farmer's thereby increasing productivity; and second by improving human capital and managerial skill of farmers to enhance their efficiency level. In other words, it is expected that an increase in the number of extension contact develops farmer's access to crop-related messages and improved technology packages.

Also, the study indicates that 48.62 percent of the households are member of a social association while 29.38 percent of the households are not member. This implies that the farmers in the study area cooperate thereby enable them to increase production and productivity of wheat. When farmers cooperate they can utilize resources efficiently and thereby increase production and productivity of wheat production. In addition, membership of a social association has advantages of accessibility to micro-credit, input subsidy and it is served as a source of information.

Table 4. 1: Descriptive results of dummy variable used in the analysis

Variables	Frequency		Percent
Sex	Male	114	58.76
	Female	80	41.24
Education	Illiterate	81	41.75
	Primary educ	60	30.93
	Secondary educ	13	6.70
Membership	Yes	137	48.62
	No	57	29.38
Manure use	Yes	139	71.65
	No	55	28.35
Land fragmentation	Yes	112	57.73
	No	82	42.27

Source: own survey result, 2019

Table 4. 2: Descriptive result of continuous variables used in the analysis

Variables	Mean	Minimum	Maximum	St.deviation
Age	44.46	24	66	11.21
Family size	4	2	10	1.67
Proximity	25.57	2	65	14.92
Amt of credit	7771.05	100	68278	6179.42
Ext contact	1	0	5	1.01

Source: own survey result, 2019

Table 4.2 shows descriptive statistics of different socioeconomic and demographic characteristics of households

4.1.4 Discussion on Input-output Variables

Table 4.3 shows descriptive statistics of both the dependent and input variables. The survey result indicates that the average amount of wheat output produced is 297.89 kg per hectare with a standard deviation of 287.9 and the difference between the minimum and maximum ranges from 100 to 2350 kg per hectare. This shows that there is a great variation of output among farmers.

The study indicates that the allocation of input variable land from a different source owned and rented is 1.65 hectares ranging from minimum and maximum of 0.25 and 2.75 hectares with a standard deviation of 0.61. On average, in the study area farmers have 1.7 oxen and the maximum number of oxen that producers own is 3.

Also, the study indicates that the average amount of improved seed used by sample households is 27.29 kg per hectares. In the study area, the amount of improved seed used ranges from10 to 48 kg per hectares, respectively. Moreover, the standard deviation of improved seed is 9.64. This implies that most of the farmers have limited access to improved seed during the production period of 2019. The average amount of improved seed is very little relative to the recommended improved wheat seed rate, 150kg per hectares (YDARoD, 2019). The average laborers participated in wheat production is 12.47 while the minimum and maximum are found to be 8 and 20 persons, respectively.

Another important input variable used for wheat production is chemical fertilizer and farmers use on average 145.81kg per hactares. Also, the minimum and maximum amount of chemical fertilizer used in the study area is 50 and 780 kg per hectares with a standard deviation of 96.17. This amount is lower than the recommended quantity of chemical fertilizers, 400 kg per hactare (YDARoD, 2019). The low level of chemical fertilizer attributes due to its high price, lack of knowledge about its importance and the recommended rate applied per hectare as a consequence of the absence of extension service. The study is consistent with Mohamed (1996).

Table 4. 3: Summary of variables used in the production function

Variable	Observation	Mean	Minimum	Maximum	St.deviation
Output	194	297.89	100	2350	287.94
Land	194	1.65	0.25	2.75	0.61
Oxen	194	1.5	1	3	0.51
Labor	194	12.47	8	20	0.61
Fertilizer	194	145.81	50	780	96.17
Improved Seed	194	27.29	10	48	9.64

Source: Survey result; 2019

4.2 Econometric Analysis

Variance inflation factor and contingency coefficient were applied to test perfect multicollinearity problem for continuous and dummy variables respectively. The VIF for variables in the stochastic frontier and Tobit model is less than 10 which shows the absence of perfect multicollinearity. Result of contingency coefficient for dummy variables is less than 0.75, implying that there is no perfect multicollinearity problem. Besides, the data was tested against heteroscedasticity problem using Breusch- Pagan test. The test result indicates that there was no heteroscedasticity problem in both models because the chi-square is greater than 5%.

4.2.1 Parameter Estimate of Stochastic Production Frontier

To analyze technical efficiency of farmers in the study area, stochastic production frontier model was specified. The Maximum likelihood estimation (MLE) technique was applied to estimate the unknown parameter of the model. Because of the non-negative assumption of the inefficiency term (u_i), the underlying distribution is non-normal and the error terms are therefore asymmetrically distributed. Hence, the ordinary least square is inefficient. Schmidt and Knox Lovell (1979) argued that the MLE technique provides more efficient estimates than OLS, besides, its guarantee of non-negative assumption of the error term. For this study, five input variables (labor, land, oxen, fertilizer and improved seed) are used for the analysis of production function.

Table 4. 4: Maximum likelihood estimate for parameters in SPF

Variables	SPFmodel	
	Coefficients	Z-ratio
Constant	3.65	3.49***
Lnseed	0.28	1.66*
Lnox	0.36	2.16**
Lnfert	0.30	2.61***
Lnlab	0.59	1.65*
Lnlad	0.12	1.17
Lambda(λ)	5.15	33.71*
Gamma	0.96	
Log-likelihood function	-272.88	

Source: Model output; 2019

Remark: ***, **and*shows that Significant at 1, 5 and 10 percent, respectively.

The econometric result presented in table 4.4 indicates that log (improved seed, fertilizer, labor and oxen) found to be positive and statistically significant. Besides, log (improved seed, labor, fertilizer and oxen) have a coefficient of 0.28, 0.59, 0.30 and 0.36, respectively. This implies that an increase at a certain optimal levels of these inputs would increase the level of wheat output. However, log land is positive but insignificant at 10 percent level of significance. It indicates that farmers have been overused the land for wheat cultivation. Hence, farmers have to utilize the land efficiently by improving their fertility. Traditionally, most farmers improve their farmland by sowing animal dug and plant residuals during the sowing season and this is an important way of increasing the quality of land thereby increase the level of the output.

Similar to the current study, Al-Awad (1994) found that wheat area was not significant, because the majority of wheat producers were having more or less the same land. In sum, the Maximum likelihood estimation of SPF, reveals that the value of gamma (γ) is 0.96 which shows a deviation of output from frontier due to the inefficiency of the farmers. Farmer lost the potential efficiency level 96 percent due to their inefficiency whereas the rest 4 percent is due to random shocks, out of farmer's control.

4.2.2 Elasticity of Production Function

The Cobb-Douglas production function was found to be an adequate representation of the data, given the specification of the corresponding translog production function, hence, the estimators are average elasticity of production. It shows the responsiveness of output due to the change in inputs. The magnitude of the elasticity of each variable is less than unity elastic implies a unit increase in the respective input would result in less than a unit increase in wheat output. The result reveals that labor has the highest elasticity followed by the amount of number of oxen, chemical fertilizer and improved seed.

The elasticity of wheat output concerning labor (0.59) is positive and statistically significant at 10 percent level of significance. According to Robinson et al,. (1997), high elasticity of labor indicates the response of household (labor supply) to policy shocks. Labour elasticity for this study is interpreted as a percentage increases in labor participants would increase the level of wheat output by 59 percent, on average. Hence, in the study area, labor is the most potential input for the production of wheat.

The second most important elasticity of wheat output is related to a number of oxen used having an elasticity coefficient of 0.36 and significant value at 5 percent level of significance positively. Therefore, the elasticity value of output concerning number of oxen (0.36) shows that wheat output will increase by 36 percent when the number of oxen used increased by a single ox.

The elasticity of wheat output concerning fertilizer input (0.30) is positive and statistically significant at1percent level of significance. It implies that at 1percent increase in the amount of fertilizer used would result a 30 percent increase in the total amount of wheat produced. Thus, farmers can produce more output of wheat by increasing the amount of fertilizer used.

Another important input having higher elasticity is improved seed which is positive and significant at 10 percent level. The elasticity coefficient of output concerning seed is 0.28 which indicates that the unit increase in improved seed could raise the quantity of wheat produced by 28 percent. Thus, the farmers can raise wheat production by using more quantity of improved seed.

The last concern of elasticity analysis is related to the responsiveness of wheat yield to land input. A one percent increase in the land will increase wheat yield by 12 percent. In sum, the results indicating that the increase in wheat yield has its highest responsiveness to labor followed by number of oxen, amount of fertilizer and improved seed.

4.2.3 Estimation of Technical Efficiency

Following the MLE procedure, the level of technical efficiency is determined. The mean level of technical efficiency for wheat production is estimated to be 37 percent. Technical efficiency is a relative concept and this value implies that farmers are on average 37 percent efficient compared to the most efficient farmer. Therefore, on average, farmers can increase output they are obtaining now by 63 percent without increasing the existing inputs.

In other words, on average, farmers can decrease inputs by 37 percent to get the current level of output they obtained if and only if they use inputs efficiently. The technical efficiency of specific crops reported by other studies was relatively low, for example, Solomon (2014) explained that the technical efficiency of sorghum production in Ethiopia was found relatively to be inefficient, having a 28 percent average level of technical efficiency. Also, Ali et al., (1994) estimated the average technical efficiency for rice production in Pakistan was 24 percent. Hence, specific to the current study, the relatively low level of technical efficiency has to be addressed. It is possible to raise the efficiency of farmers through knowledge and skill improvement, training and update information. Besides, improvement of farmer's awareness on the use of modern agricultural inputs such as quality seed and a sufficient amount of fertilizer can increase efficiency. Besides, farmers can increase technical efficiency through land management practices and agricultural technologies.

In the study area, farmers are not equally efficient and there is significant technical efficiency variation across them. About 52.56 percent of the farmers have technical efficiency score of value less than the average technical efficiency. However, only 47.44 percent of the farmers in the study area have technical efficiency greater than the mean level. This is an indication that most of the farmers use their resources inefficiently for wheat production.

Table 4. 5: Distribution of TE for sample farmers in the study area

TE range	Frequency	Percentage
0.00-0.3	86	44.33
0.31-0.4	16	8.23
0.41-0.5	23	11.86
0.51-0.6	27	14.95
0.61-7	22	11.34
0.71-0.8	7	3.61
0.81-0.9	11	5.67
0.91-1.00	0	0
Sum	194	100
Mean TE	0.370	
Min	0.001	
Max	0.853	

Source: Own calculation; 2019

4.2.6 Determinant of Technical Inefficiency

The primary aim of estimating the level of technical efficiency is to investigate factor that affects technical efficiency of farmers in the study area. Various hypothesized variables that are expected to determine efficiency difference among farmers were estimated.

There are socio-economic, demographic and environmental, institutional and non-physical factors that affect technical inefficiency of households (Kumbhakar and Bhattachandry, 1992). These factors can be categorized into three groups as it is explained below.

4.2.6.1 Demographic Factors

Demographic factors are a group of factors related to the status of the household like sex, age and family size and educational level of the household head.

The effect of age on technical inefficiency could be negative for some ranges and positive for the remaining ranges (Table 4.7). That is why it is specified in the quadratic form age and age squared of the household head. During young age, farmers are relatively more productive until certain age levels and soon after diminish as they become older and older (Ike and Inoni, 2006). This is due to agricultural activity is more laborious and needs more effort. Battese and Coelli (1996), Dinar et al., (2007), Anik (2012) and Rahman eta.,(2012) support that young farmers are less efficient than the older farmers until certain level because older farmers have farming experience on how to optimize resources to produce more output. The current study confirms the above findings and other findings such as Abebaw (2003), Shumet (2012), Solomon (2014), Kinde (2005) and Fekadu (2004).

The coefficient of family size indicates a positive association between family size and technical inefficiency. This implies that households with large family sizes are less efficient because large family size requires additional household consumption expenditure thereby reduces the amount of resource mobilized for production. Also, the selected family member may be young which have no contribution to agricultural production. However, this result is inconsistent with Obwona (2006), Hisano et al.,(2008) and Al-Hassan (2012). In sum, the sign of family size is inconsistent with the prior expectation though the result is as it was expected.

The result indicates that illiterate, primary school and secondary school education are statistically significant at 10 levels of significance. Illiterate and primary school education influences technical efficiency positively while secondary school education influences negatively. Education promotes the acquisition and the utilization of information on improved technology farmers. Farmers who are educated are more technically efficient. The finding agrees with Liu and Zhuang (2000), Tirkaso (2013), Khai and Yabe (2011) Hassen (2016), Wudineh and Endrias (2015) and Fasasi (2007) except the sign of illiterate and primary school education is different.

4.2.6.2 Resource Endowment Factors

These inefficiency variables includes proximity, land fragmentation and manure application. It was hypothesized proximity would have a significant impact on the production of wheat.

The result of the study showed that the coefficient of proximity is negative and statistically significant at1percent level of significance. This implies that the variable is an important factor influencing the level of efficiency. Farmers living away from the farm area would operate more farming activity relative to a farmer who works nearest to a farm area. The result is inconsistent with the finding of Wudineh and Endrias (2015).

Manure use has a significant positive effect on technical inefficiency. It is statistically significant at 10 percent level of significance. The sign of manure use is not similar it was as expected but the result is it was as expected. However, the estimated result implies that farmers who apply manure to their farm are less efficient than those who don't apply. It is maybe the farmers who apply manure may not apply properly.

Moreover, the result shows that estimated land fragmentation has a positive influence on technical inefficiency. This because farmers having fragmented land spend more time moving over scattered plots and face management problems. The result confirmed with Fekadu (2004) who indicates that farmers having more fragmented and scattered land would be less efficient than who have less or have not at all. Wan and cheng (2001) also conclude that Chinese agriculture could improve its output by eliminating land fragmentation. This is because an excessively large number of plots of land indicates significant land fragmentation.

4.2.6.3 Institutional Factors

Institutional factors consist frequency of extension contact, amount of credit and membership of a social association.

The result indicates that the coefficient of amount of Credit is positive and statistically significant at 10 percent level of significance, indicating that the provision of credit to farmers decreases farming efficiency. This is because credit may not appropriately be used for agricultural activities. In other words, an inefficient farmer may be selected due to selection bias. This result contradicts Simonyan et al., (2011) and Kinde (2005) finding's. In sum, the sign is inconsistent with previous expectations but the result is as expected.

The parameter estimate of membership is negative but statistically insignificant at 10 percent level of significance. The result of the study revealed that engaged to the social association is found to influence technical inefficiency as it was expected, indicating that farmers who belong to one of social associations perform farming activity better than who are not engaged to the association. Therefore, farmers involved in social association would have access to credit, better information about technologies related to improved inputs (seed, chemical fertilizer) and agricultural practices such as pesticide, insecticide and crop rotation. This finding is not uniform with the finding of Wudineh and Endrias (2015).

The estimated coefficient of extension contact has a negative impact on the technical inefficiency of farmers. The extension service provided to households plays a crucial role in creating potential to improve the overall performances of farm productions through access to better information on new technologies. It was hypothesized that farmer having more contact with extension experts, would be more efficient. The result revealed that frequency of extension contact found to be negative and significant at 10 percent level of significance. Similar effects of extension contact on technical inefficiency of farmers are also reported in other studies by Obwona (2006), Binam et al., (2008), Nyagaka etal., (2010), and Abba (2012). However, this study is contrary to Hasson et al., (2000).

Table 4. 6: Determinant of on technical efficiency among farmers

Inefficiency Variables	Coefficients	Standard error	t-ratio
Sex	-0.05832*	0.034	-1.72
Age	-0.00071	0.006	-0.12
Age square	0.00001	0.000	0.16
Fsize	0.02181*	0.013	1.76
Illiterate	0.07210*	0.041	1.80
Prischool	0.07549*	0.044	1.70
Secschool	-0.12406*	0.065	-1.90
Proximity	-0.00402***	0.001	-3.70
Extcontact	-0.02697*	0.016	-1.73
Amtcredit	4.12e-06*	2.43e-06	1.70
Manure	0.07623**	0.038	2.03
Membership	-0.00575	0.037	-0.16
Lanfragmnt	0.06592**	0.033	2.01
Constant	0.55848***	0.153	3.64

Source: Output result, 2019

Note***: ****,*** ** and* indicates 1percent, 5percent and 10 percent level of significant

Marginal Effect of Inefficiency Variables

The estimated parameters on technical inefficiency model represents the direction of the effect of inefficiency variables. According to Battese and Coelli (1993), quantification of the marginal effect of inefficiency variables on technical inefficiency was done by partial differentiation of the inefficiency predictor with respect to each variables in the inefficiency model. Fortunately, for this study the marginal effect and the estimated parameter in Tobit model are similar implies that the estimates can be interpreted as usual using OLS techniques (see Table 4.7 and appendix 9).

The estimated coefficient of sex dummy (-0.05832) implies that the male headed household's technical efficiency less than female one by 5.832 percent. If the household head is male his technical inefficiency decreased or technical efficiency is increased by 5.832 percent. The result is consistent with Kibaara and Kavio (2012) and Hisano etal., (2008).

In contrast, the marginal effect of age is -0.0070 (-0.0007114+0.0000107), implying that technical inefficiency declines by 0.7 percent as the household heads become older and older until they reach a certain age level. After that age level, inefficiency may begin to increase because experience on farming may decline and marginal effect improvement on technical efficiency may decrease.

The coefficient of illiterate (0.07299) indicates that illiterate farmers are 7.299 percent inefficient than farmers who have primary and secondary school education. On the other hand, the marginal effect of primary school education on efficiency (0.07549) indicates that the farmer's inefficiency increases by 7.549 percent. In addition, the estimated coefficient of secondary school education (-0.12406) shows that the inefficiency level of farmers with secondary school education is reduced by by12.406 percent. Thus, the result shows that farmers who have secondary school education are more efficient. The coefficient of manure application (0.07623) indicates that manure user farmers have technical inefficiency of more than 7.623 percent than their counterparts. In other words, farmers who apply manure are less efficient than the non-user one. The result also shows that the farmer's technical efficiency is declined by 0.402 percent as farm distance from farmer's home increases by one minute. The estimated coefficient of extension contact (-0.02697) indicates that the technical efficiency of farmers increases by 2.697 percent as they communicate frequently with the extension experts. The increase in extension contact increases technical efficiency or the more extension visit farmer obtains, the higher will be their level of technical efficiency. The coefficient of land fragmentations is 0.06592 and it indicates household head having fragmented land, his technical efficiency decreases by 6.592 percent than its counterparts. Having more plots of land results in inefficiency by creating a shortage of family labor, costing time and other resources that should be available at the same time. This result is in line with Fekadu (2004) and Tipi et al., (2009). The coefficient of family size (0.02181) implies that as household's family size increases by a member, technical inefficiency increases by 2.181percent. This is because most of the household members who are still at a very young age may not be able to contribute to the family labor supply.

5 CONCLUSION AND POLICY IMPLICATION

5.1 Conclusion

This study is conducted based on the primary objective of analyzing the technical efficiency of wheat production and identifying factors affecting technical efficiency in the Yilmana Densa district. The analysis used cross-sectional data collected from 194 sample farmers through a random sampling procedure during the 2019 production year. Stochastic production function was applied to analyze technical efficiency while Tobit model was used to estimate socioeconomic factors that determine the level of technical efficiency of wheat production in the district. The result of the estimated Cobb-Douglas stochastic production frontier model indicates that input variables such as improved seed, fertilizer, oxen, land and labor were the essential determinants of production level of wheat production. The Coefficient of all input variables except land were significant, indicating that increasing the use of these inputs will promote the production of wheat. The maximum likelihood estimation of SPF, reveals that the value of gamma (γ) is 0.96 which shows deviation from the frontier due to the inefficiency of the farmers. Farmer lost the potential efficiency level 96 percent due to their inefficiency whereas the rest 4 percent is due to random shocks, out of farmer's control.

The result of efficiency analysis indicates that mean technical efficiency was 37percent ranging from 0.001 to 0.853. This implies that there exist excess potential to enhance production to the production frontier. In other words, this indicates that farmers in the study area are more inefficient even the majority of the farmers have efficiency below the average level.

As far as the inefficiency effect model concerned, socio-economic and institutional factors which are the principal determinant of efficiency was analyzed. The socio-economic and institutional variables were identified to affect the efficiency of farmers includes sex, illiterate, primary and secondary school education, age, family size, extension contact, membership and manure application, proximity, amount of credit and land fragmentation. Out of these inefficiency variables sex, secondary school education, extension contact, and proximity are found statistically significant. Amount of credit, family size, illiterate, primary school education, land fragmentation and manure are positive significant while the remaining and age and age square and membership have no impact on the production of wheat in the study area. Sex of the household found to be a significant factor in affecting the efficiency of farmers. The result revealed that the male-headed household head is more efficient than their counterparts. It shows that unlike males, female have no opportunity to get access to credit, get involved in meeting and training,

The technical efficiency of selected farmers was highly affected by proximity positively though this violates previous expectations. This is maybe due to farmers does not waste more time in the village talk. A farmer with distant farm areas will continue working there for a long time than its counterparts whose farm area is near to home. On the other hand, farmers with farmland near to its home will waste more time during breakfast time and launch time and even maybe addicted to the village talks with people to stay around there. In this case, a farmer with distant farmland from home would be more efficient.

The family size of the household is one of among other policy variables considered to influence the efficiency of farmers. The result shows a positive effect on the family size on technical efficiency. Land fragmentation was found to be one of the significant variables influencing the technical efficiency of wheat production. According to this study result, it affects technical efficiency significantly. Credit is the most essential variable influencing the technical efficiency of a farmer in the study area. Credit relaxes the financial constraint of farmers faced in production. This is because financial constraints are an obstacle for production efficiency but can be reduced through a significant amount of credit. In this study amount of credit affects technical efficiency positively.

In general, the finding of the study indicates the demand for policy formulation and practice to improve farmer's efficiency to produce the maximum level of output. Also, the existence of inefficiency level in wheat production and identification of socio-economic and institutional factors would have policy implications in improving the productivity of wheat in the study area.

5.2 Policy Implication

Based on the finding, it is attempted to suggest recommendations to the concerned body. The result of the study enable policymakers primarily to sort out factor impedes the efficiency of farmers and then to make the right decision on how to improve technical efficiency and to use optimal use of the resource. First, since improved seed and sufficient fertilizer enhance production and productivity, cooperation has to be made by the concerned body at the district level, zonal level and regional level to ensure farmers access to quality seed and sufficient fertilizer. Farmer's application of modern inputs on the farm field needs to be supported by experts and extension workers. Encourage and show manure use to farmers on their farm parallel to chemical fertilizer increases yield.

Second, promote the educational status of farmers to create awareness on farmers about agricultural technology and the best agricultural practice. The education can be given in the form of meetings, training and in other formal or informal ways. To accomplish this task human and infrastructure like extension works and farmers training centers (FTCs) may be used.

Third, motivate and encourage gender-specific agricultural intervention to improve female-headed farm efficiency. This is the best mechanism to reduce female-headed household farm inefficiency. Giving training to females regarding agricultural production can improve their participation.

Fourth, to mitigate financial constraint both governmental and non-governmental organization focuses to establish and strengthen microfinance and agricultural cooperatives to meet credit interest of the farmers with appropriate interest rate.

Fifth, in this study family size, affects technical efficiency positively to the improvement which reminds that the family planning program was not powerful influence the average family size. Therefore, it should be strengthened to minimize the average family size over time.

Sixth, devise a policy that promotes to experience sharing among farmers related to the utilization of intermediate inputs such as quality seed and fertilizer would permit farmers to improve productivity. This reminds that policymakers should not simply introduce and disseminate inputs to reduce the low level of productivity of wheat.

Finally, the availability of technical inefficiency in the study area shows that all the concerned bodies form integrated and scientific development effort that leads increase in the existing level of input use and necessary measures that will decrease the existing level of inefficiency of farmers.

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APPENDIX

Appendix 1: Household Questionnaire

Dear respondents: my name is kindie Abetie, M.Sc student at BahirDar University conducting a research on technical efficiency of wheat production in YilmanaDensa District. This questionnaire is designed to collect data about your point of view on wheat yield and relevant inputs in your kebele. Hence, you are kindly requested to cooperate by providing your response. Whatever information you provide, it will be strictly kept confidential and will not show to other persons.

Instruction: Your name will not be included. Please tick (mark) your response in the box. You can give more than one answer to each question wherever necessary.

1. Sex of household head: 1= male 0= female
2. Age of household head:______________
3. Education level of household head:
   - A. 1= Illitrate 0= otherwise
   - B 1= Primary school education 0= otherwise
   - C 1= High school education 0= otherwise
4. Total family size:_____________
5. How much hectare of wheat land do you have?__________________
6. Walking distance from home to your plot of land ______ minute.
7. The total amount of wheat yield in 2018/19 is _____________________in Kilogram.
8. How many total number of labors you have used for the production of wheat in 2018/19?
9. Did you have access to extension services about wheat production in 2018/19?

   1= Yes 0=No
10. If so, how many times per year are you visited by extension service provider(s)? ______
11. How many numbers of oxen used in the production of wheat in2018/19? ____________
12. Have you borrowed money from microfinance?

1=Yes 1= No

13. How much money you have borrowed:_________________birr

14. For what purpose do you use the credit?

A. To buy farm input like quality seed, fertilizer and insecticides
B. To make a house for living
C. To buy food for the households
D. Other specify ___________________

15. Is there a time that you do not use credit, if so why?

A. Shortage of micro finance specify
B. High interest rate
C. Lack of collateral
D. No need of credit
E. Other specify ____________________

16. What is your source of credit?

A. Relatives and friend
B. Government institution/ACSI
C. Money lenders
D. Others specify____________________

17. Have you used improved wheat seed?

A. Yes B. No

18. If yes, what is the amount of improved wheat seed you have used in kilogram per hectare?

19. If you do not use improved wheat seed, what is the reason?

A. Expensive
B. Not better than local seed
C. Lack of credit to buy the seed
D. Other specify_______________

20. Have you used chemical fertilizer to improve the productivity of wheat production?

1=Yes 0= No

21. If you don't use what is the reason?

A. High price
B. Fertilizer is not available
C. Lack of credit to buy it

D. Other specify ___________

22. Did you use manure for wheat production in the 2018/19 production year?

1= Yes 0 = No

23. Are you a member of social networks

1= Yes 0= No

24. Is it your landfragmanted?

1=Yes 0= No

Appendix 2: VIF for variables in the stochastic production frontier model

estat vif

Variable	VIF	1/VIF
lnfert	1.03	0.974408
lnlad	1.01	0.985366
lnseed	1.01	0.985596
lnlab	1.01	0.991855
lnox	1.00	0.997708
Mean VIF	1.01	

Appendix 3: VIF for continuous inefficiency variables

. vif

Variable	VIF	1/VIF
agesqr	16.08	0.062170
age	15.74	0.063522
fsize	1.63	0.612539
extecontact	1.04	0.961689
amtcredit	1.03	0.974942
proximity	1.03	0.975056
Mean VIF	6.09	

Appendix 4: Contingency coefficient for dummy variables in inefficiency effect model

```
. pwcorr sex manure membership lanfragmnt illtrate prischool secschool
```

	sex	manure	member~p	lanfra~t	illtrate	prisch~l	secsch~l
sex	1.0000						
manure	-0.0042	1.0000					
membership	0.1333	0.0951	1.0000				
lanfragmnt	-0.0083	-0.0231	0.0437	1.0000			
illtrate	0.0591	0.0690	-0.0711	-0.0007	1.0000		
prischool	-0.0606	-0.1616	0.0542	-0.0174	-0.5158	1.0000	
secschool	0.0578	0.1391	0.0288	0.1048	-0.1694	-0.1886	1.0000

Appendix 5: Heteroscedasticity test for the stochastic production function

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnY

         chi2(1)      =    37.26
         Prob > chi2  =   0.0000

.
```

Appendix 6: Stochastic production frontier Cobb-Douglas functional result

Stoc. frontier normal/hnormal model

Number of obs = 194
Wald chi2(5) = 21.75
Prob > chi2 = 0.0006

Log likelihood = -272.8777

lnY	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
lnox	.3613969	.1663729	2.17	0.030	.035312	.6874818
lnseed	.2737632	.1661664	1.65	0.099	-.051917	.5994434
lnlab	.589957	.3574129	1.65	0.099	-.1105595	1.290473
lnfert	.3075362	.1166068	2.64	0.008	.0789911	.5360814
lnlad	.1221996	.1035802	1.18	0.238	-.0808139	.3252131
_cons	3.645167	1.046903	3.48	0.000	1.593274	5.69706
Usigma						
_cons	1.052573	.1351134	7.79	0.000	.7877556	1.31739
Vsigma						
_cons	-2.226448	.3862835	-5.76	0.000	-2.983549	-1.469346
sigma_u	1.692635	.1143488	14.80	0.000	1.482719	1.932269
sigma_v	.3284982	.0634467	5.18	0.000	.2249731	.4796623
lambda	5.152645	.1519128	33.92	0.000	4.854902	5.450389

Appendix 7: Stochastic frontier translog functional result

Stoc. frontier normal/hnormal model Number of obs = 194
Wald chi2(20) = 42.86
Prob > chi2 = 0.0021

Log likelihood = -264.1214

lnY	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
lnox	-1.861953	4.263259	-0.44	0.662	-10.21779	6.493882
lnseed	1.49781	4.829996	0.31	0.756	-7.968808	10.96443
lnlab	-1.524372	9.824238	-0.16	0.877	-20.77952	17.73078
lnfert	1.76057	2.46663	0.71	0.475	-3.073937	6.595076
lnlad	.5970334	2.40047	0.25	0.804	-4.1078	5.301867
LnLab2	-1.002963	1.663257	-0.60	0.547	-4.262887	2.256961
LnFert2	-.0242242	.1449209	-0.17	0.867	-.308264	.2598156
LnLad2	.367858	.1646795	2.23	0.025	.0450922	.6906238
LnSeed2	-.1118099	.4098756	-0.27	0.785	-.9151514	.6915316
LnOx2	.0302489	1.931979	0.02	0.988	-3.756361	3.816859
LnoxLnLab	1.49656	1.064213	1.41	0.160	-.5892597	3.582379
LnoxLnfert	-.1780061	.4423281	-0.40	0.687	-1.044953	.6889411
LnoxLnlad	-.2086464	.366283	-0.57	0.569	-.9265479	.5092551
LnoxLnseed	-.1390904	.5375655	-0.26	0.796	-1.1927	.9145187
LnlabLnfert	.4910264	.8952342	0.55	0.583	-1.2636	2.245653
LnlabLnlad	.5896446	.7950893	0.74	0.458	-.9687018	2.147991
LnfertInseed	-.6709406	.413284	-1.62	0.104	-1.480962	.139081
LnladLnseed	.0365207	.434206	0.08	0.933	-.8145073	.8875488
_cons	.8729977	19.43931	0.04	0.964	-37.22736	38.97335
Usigma						
_cons	.9868248	.1624542	6.07	0.000	.6684205	1.305229
Vsigma						
_cons	-2.462795	.6563885	-3.75	0.000	-3.749292	-1.176297
sigma_u	1.637896	.1330415	12.31	0.000	1.396837	1.920556
sigma_v	.2918844	.0957948	3.05	0.002	.1534092	.5553546
lambda	5.611453	.2088975	26.86	0.000	5.202022	6.020885

Appendix 8: Tobit regression result of the inefficiency effect model

```
Tobit regression                                  Number of obs   =        194
                                                  LR chi2(13)     =      40.15
                                                  Prob > chi2     =     0.0001
Log likelihood =  16.902736                       Pseudo R2       =     6.3264
```

TI	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
sex	-.0583213	.0339972	-1.72	0.088	-.1254031	.0087606
age	-.0007114	.0057913	-0.12	0.902	-.0121387	.0107158
agesqr	.0000107	.0000651	0.16	0.869	-.0001178	.0001393
fsize	.0218108	.01309	1.67	0.097	-.0040178	.0476393
proximity	-.0040283	.0010891	-3.70	0.000	-.0061773	-.0018794
extecontact	-.0269665	.0156209	-1.73	0.086	-.057789	.0038559
manure	.0762267	.0375952	2.03	0.044	.0020455	.1504078
amtcredit	4.12e-06	2.43e-06	1.70	0.092	-6.74e-07	8.91e-06
membership	-.0057486	.0361504	-0.16	0.874	-.0770791	.0655818
lanfragmnt	.0659249	.0328644	2.01	0.046	.0010782	.1307716
illtrate	.0729994	.0406175	1.80	0.074	-.0071453	.153144
prischool	.0754852	.044384	1.70	0.091	-.0120914	.1630618
secschool	-.1240569	.0652011	-1.90	0.059	-.252709	.0045952
_cons	.5584827	.1532961	3.64	0.000	.2560054	.86096
/sigma	.2217807	.0112592			.1995646	.2439969

Appendix 9: Estimation of the Marginal effect of inefficiency variables

```
. mfx

Marginal effects after tobit
      y  = Linear prediction (predict)
         =  .62719694
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
sex*	-.0583213	.034	-1.72	0.086	-.124955	.008312	.592784
age	-.0007114	.00579	-0.12	0.902	-.012062	.010639	44.4639
agesqr	.0000107	.00007	0.16	0.869	-.000117	.000138	2082.75
fsize	.0218108	.01309	1.67	0.096	-.003845	.047467	3.79381
proxim~y	-.0040283	.00109	-3.70	0.000	-.006163	-.001894	25.701
exteco~t	-.0269665	.01562	-1.73	0.084	-.057583	.00365	1.0567
manure*	.0762267	.0376	2.03	0.043	.002542	.149912	.731959
amtcre~t	4.12e-06	.00000	1.70	0.090	-6.4e-07	8.9e-06	7654.65
member~p*	-.0057486	.03615	-0.16	0.874	-.076602	.065105	.706186
lanfra~t*	.0659249	.03286	2.01	0.045	.001512	.130338	.57732
illtrate*	.0729994	.04062	1.80	0.072	-.006609	.152608	.402062
prisch~l*	.0754852	.04438	1.70	0.089	-.011506	.162476	.283505
secsch~l*	-.1240569	.0652	-1.90	0.057	-.251849	.003735	.082474

(*) dy/dx is for discrete change of dummy variable from 0 to 1