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ANALYSIS OF RED PEPPER PRODUCTION RISK ADJUSTED TECHNICAL EFFICIENCY: THE CASE OF LANFURO DISTRICT IN SILTIE ZONE, SOUTHERN ETHIOPIA

MUKTAR GELETO, MOHAMMED ESSA

Abstract:

This study objective was to add the additional empirical findings on the works of literature, that explain the possible causes of red pepper yield fluctuations in the study area. The output gap that exists between observed and the potential output indicates an opportunity for further output growth. To estimate the production risk and technical inefficiency effects the study was employed a cross-sectional data that collected from 320 sampled red pepper farmers in the study area. The results of the study confirmed that the translog (transcendental logarithmic) production model specification was the best-fitted model. To estimate the level of technical efficiencies, this study was employed the stochastic frontier model with flexible risk properties that able to considered production risk. Hence, the output fluctuation is evaluated from both production risk and technical inefficiency sources. The estimations results of the mean output, production risk and technical inefficiency models provided by using a one-step maximum likelihood in the sfcross command with STATA16 software. The study justifies the presence of technical inefficiency and production risk in the red pepper production process. The input variable fertilizer, seed, another cost of agrochemicals and labour positively affect the red pepper output. The study also shows that the red pepper production technologies exhibit increasing returns to scale in the study area. Fertilizer, seed, costs of agrochemicals reduce output risk whilst labour increase output risk but its effect was insignificant. This study finding demonstrates that the causes of technical efficiency differentials among sampled red pepper farmers in the study area. The average technical efficiency scores of red pepper farmers are 62.5 per cent in the study area. There is a significant difference between the estimations of the production risk-adjusted and not adjusted averages technical efficiencies. The market information, extension contact, and gender being head household positively related to technical efficiency. The age of household head, the prevalence of diseases, family size and education at college and above level negatively related to technical efficiency. This study recommends that inputs for red pepper production should be made readily available, affordable and accessible to farmers so that more may be employed to further increase output.

Keywords:

Red Pepper, Flexible Stochastic Frontier Model, Production Risk-adjusted Technical Efficiency, Cobb-Douglas Production Function

JEL Classification: F00, A19, B50

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INTRODUCTION

1.1 Background of the Study

In the world literally, all countries produce red pepper. The production of this crop is estimated about 690,467ton from 568,299 hectares of land. The world highest pepper producer countries are Vietnam (252,576 ton), Indonesia (87,029ton), Brazil (79,371ton), India (72,000), Bulgaria (54,820ton) and China (35,389).These six highest pepper producer countries have 84% contribution for world total pepper production. The world average pepper productivity is 12.15 quintal per hectare. African contribution to world pepper production is very small, which is about 9.3% and its average productivity is 6.82 quintal per hectare (FAO STATA, 2017).

Ethiopia has wide possibility that able to produce varieties of peppers in different agroecology's. Hence, this enables the country become the largest pepper producer in Africa (Abate *et al.*, (2019). Country's` pepper production accounts about 75.41%, of the total area covered by vegetables. High potential pepper producing areas of Ethiopia are central (eastern and northern Shewa), western, northern (Wollega, Gojjam) and Southern Ethiopia particularly Halaba, Siltie, Hadiya Mareko and Meskan (CSA, 2017). These areas produce an adequate amount of red pepper to distribute to the deficit area. However, recently the country's red pepper productivity and output quality started to decline and the production increments was only due to area increased (Abebe & Abera, 2019). According to their argument, shortage of improved seed varieties, lack of proper and adequate inputs (fertilizers and pesticides), lack of adequate management technique, high susceptibility to disease and pest infestation and erratic rainfall or unaffordability of irrigation system to smallholder farmers are the main causes of output reduction.

The contribution of Southern region for country's total production was accounted 17.4% and 17.09% in year 2018 and 2019 respectively (CSA, 2018, 2019). This demonstrates that there was red pepper production instability. Pepper may be a dominant crop in Siltie zone is especially grown by rain fed condition. Its share from the country's production was 7.4% and its share from SNNP was 40.94% for 2016/17. However, its share from the entire production in SNNP was decreased from 44% to 40.94% in 2015/16 and 2016/17, respectively (CSA, 2016, 2017).

Lanfuro District features a good climate for vegetable production, especially for the red pepper.

Consistent with Mussema (2006) it's one among the main pepper producing area and 62% of small holder farmer’s cash income is generated from red pepper. As a result, intensification of production using improved varieties, pesticide and best management practices knowledge is important for increasing productivity on fragmented farm.

Therefore, it's reasonable to enhance red pepper farm productivity. The study intended to estimate the production risk-adjusted technical efficiency by using the flexible stochastic frontier approach. This contributes to the literature on red pepper production particularly by estimating risk-adjusted technical efficiency and the marginal effects of inputs on production risk within the study area.

1.2 Statement of the Problem

Even though Ethiopia is the largest pepper producer in Africa, recently the country’s red pepper productivity and output quality started to decline and the production increments was only due to area increased (Abebe & Abera, 2019). The result of CSA (2018), also shows that from year 2016 to 2017 the red pepper area harvested and production was increased by 26.55% and 25.5% respectively. But the yield of the crop was declined by 0.82%. This shows that smallholder farmers are technically inefficient since, they are producing below the potential output using the existing technology. According to Tenaye (2020) now a day land becomes more fragmented, therefore the crop production growth should come from yield increment.

From theoretical point of view improvement of technical efficiency and introduction of modern technologies enhance agricultural productivity and production. However, unless existing resources and technologies are efficiently utilized, the introduction of new technologies will not be cost-effective (Asefa, 2012). Therefore, efficient use of the existing technologies is more cost-effective than applying new technologies, especially for developing countries like Ethiopia.

On the other hand, small holder farmer’s decision to use existing technology and resource is affected by their inefficiency level and ability to reduce the probability of unfavorable production outcomes (Lundahl, 1987). According to Fufa and Hassen (2003) farmers can influence yield variability that induced from production risk by choice of inputs in their enterprise. Hence, this shows that the cause of yield variability from farmer to farmer is not only because of inefficient use of production inputs but also their risk management abilities. Due to this measuring technical efficiency without considering production risk on inputs result a biased estimate of efficiency (Kumbhakar, 2002).

From this, understanding the nature and determinants of technical (in) efficiency and production risk among smallholder farmers have a great importance. Few studies have undertaken to examine the technical efficiency of red pepper farmers in Ethiopia even in Africa. Some of those studies include, (Abebo (2019) ,Lagiso and Geta(2020), Mohammed *et al.* (2015), Asravor *et al.*(2015), Abate *et al.* (2019 etc.) ,all of this studies focus was only on the inefficiency component to estimate technical efficiency and marginal effects of inputs on inefficiency. This implies that the marginal effect of inputs on production risk is not considered. Therefore, this study aims to estimate the extent of and determinants of technical efficiency and the marginal effects of inputs on production risk faced by pepper farmers in the Lanfuro District.

This paper adds to the present literature firstly even though, previous studies (eg Kumbhakar 2002), Villano and Fleming (2006), Wen and Chang (2011), Oppong *et al.* (2016), Lemessa *et al.* (2017.etc.) have simultaneously estimate technical inefficiency and production risk using stochastic frontier analysis, none of these studies have considered red pepper production. Secondly, the best of my knowledge unlike prior studies, which done on pepper in Africa and Ethiopia, (Asravor et *al.* 2015; Dipeolu A.O & S.O Akinbode 2016; Abate 2019; Abebo 2019; Lagiso and Geta 2020; Mohammed *et al.* 2015), this study is the unique to estimate the technical inefficiency and the marginal effects of inputs on production risk in red pepper production. The marginal effect of inputs on production risk like drought, pest infestation not considered. Thus, study of technical efficiency needs to be extended to incorporate risk and producers' responses to risk. Lastly, the findings of above studies might not apply to the case of pepper production in the study area due to the diverse agro-ecological zone and differences in the experience of farmers. Moreover, it is a vital to update the information based on the current productivity of farmers.

Therefore, this study is designed to investigate the technical efficiency of red pepper farmers using stochastic frontier with production risk to indicate the effects of the input use on the output variance, to estimate the technical efficiency and to identify factors that affect the technical inefficiency of farmers' in the study area.

1.3 Objectives of the Study

1.3.1 General objective

- To investigate production risk-adjusted technical efficiency of smallholder red pepper farmers in Lanfuro District, Southern Ethiopia.

1.3.2 Specific objective

- To estimate extent of production risk-adjusted and not-adjusted technical efficiency of smallholder red pepper farmers in the study area.
- To identify factors those affect the technical inefficiency of smallholder red pepper farmers in the study area.
- To estimate the effect of input factors on red pepper production risk in the study area.

2. Conceptual Framework

This study was conducted based on a conceptual framework drawn from the empirical literature reviewed and explained above. The main determinant variables and methods of model specification in various research works of the literature were identified. The stochastic frontier framework on production risk was as suggested by Just and Pope (1979, 1978) and the extension of that incorporates producers' attitude towards risk (Kumbhakar, 2002). This production functions were able to explicitly capture the risk dimension in the red pepper production activities of smallholder farmers.

From the literature review above, the following graphic representation of the conceptual framework was developed.

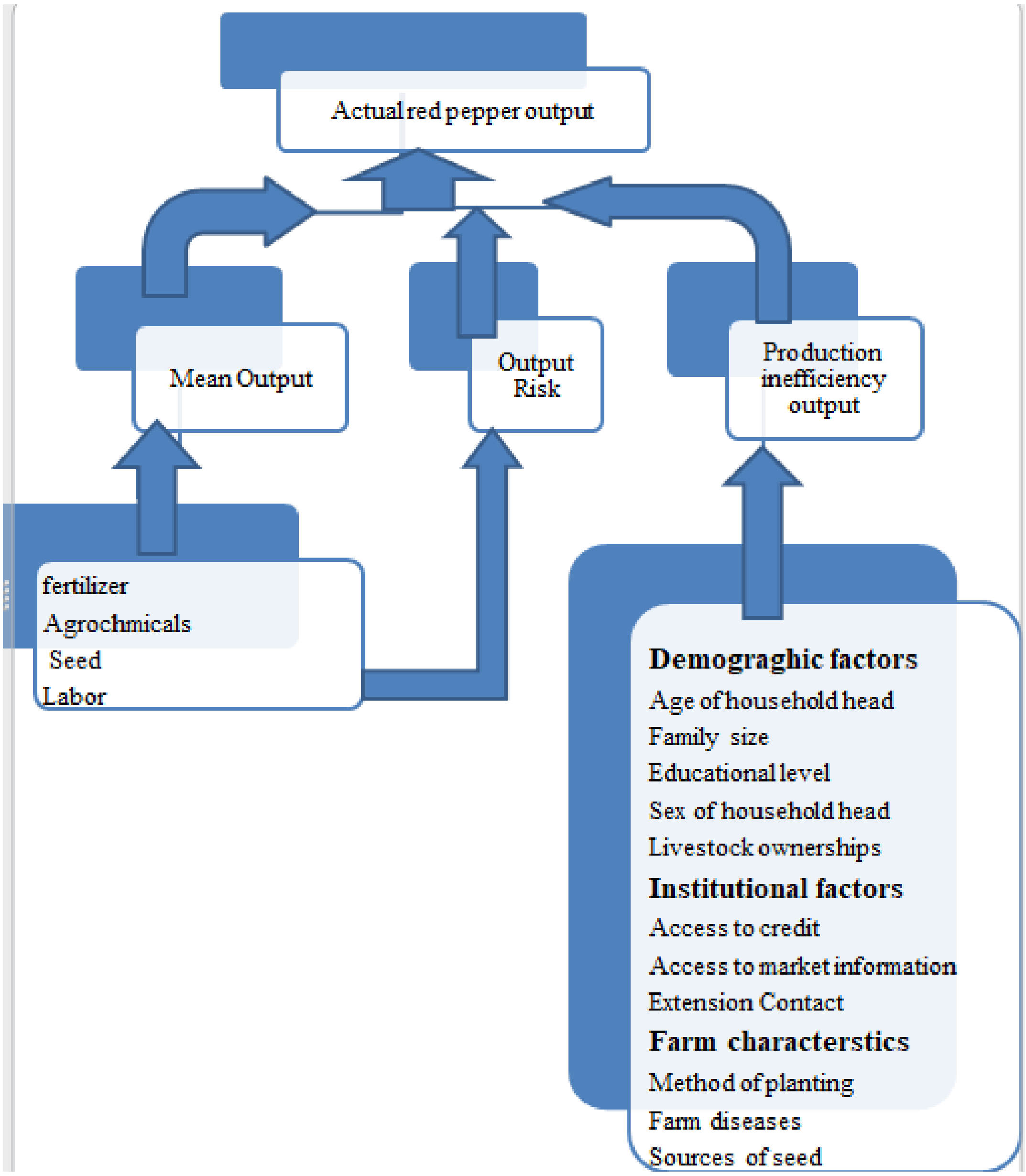


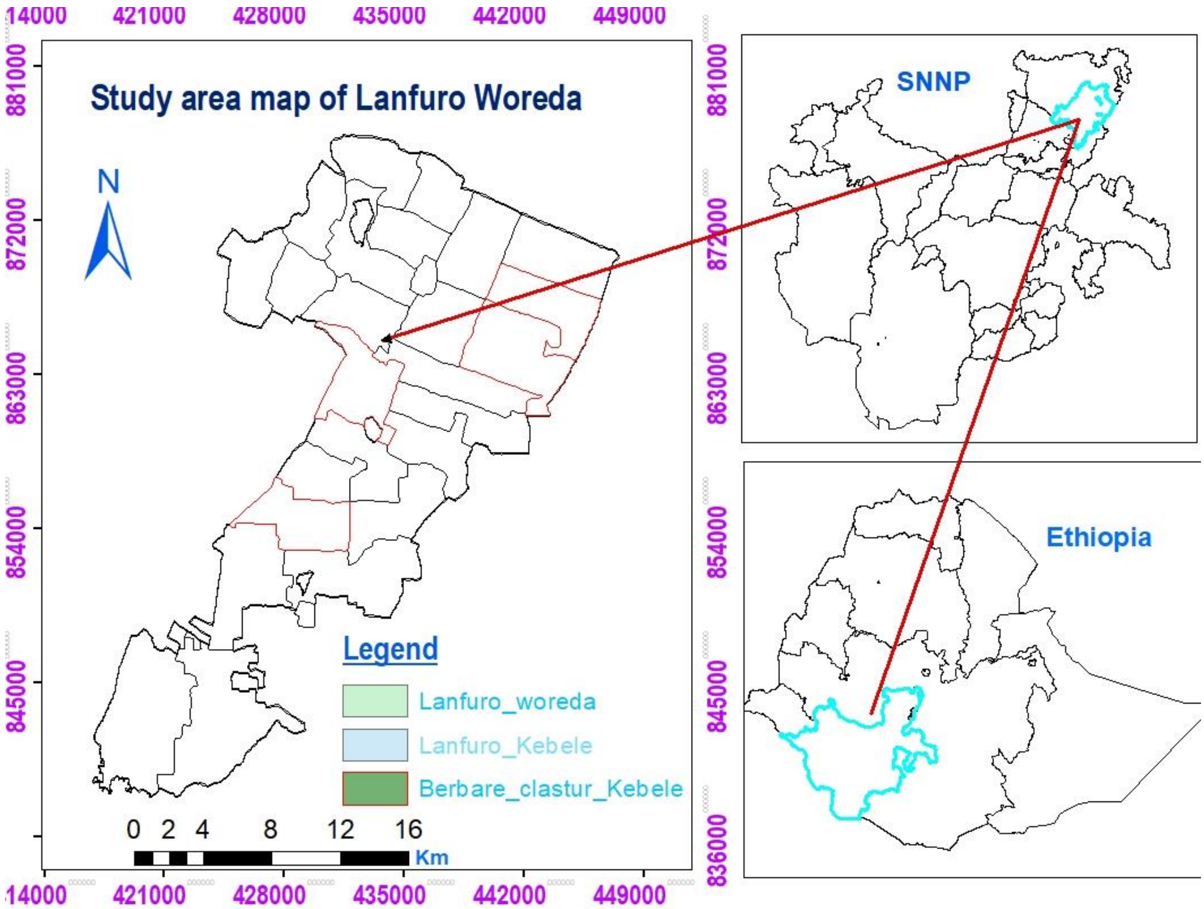
Figure 2. 1. Conceptual Framework (Source Villano & Fleming (2006)).

RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study was conducted in the Lanfuro District in the Siltie Zone; South Nations Nationalities and Peoples (SNNPR) of Ethiopia, during 2018/19 production year. The Lanfuro District is one of the eight administrative Districts found in Silte Zone of the SNNPR. It is bordered by Halaba special District to the south, Oromia region to east, Sankurra District to south west, Dalocha district to the west, and Siliti district to the north. Tora town is the administrative center of the District which if found 221 kms from Addis Ababa, 160 km from Hawassa and 38 km from the Zonal capital city of Worabe. The District has altitude ranges from 1800 to 2000 meters above sea level with a predominantly dry Woina-Dega agro-ecology. The highest and lowest temperature is 34 Celsius and 24.89 Celsius respectively. The rainfall is between 1000 and 1100ml.

Figure 3. 1 Map of the Study Area



3.2 Sampling Procedure and Sample Size Determination

The study was done based on the formal survey method that used selecting a representative sample from a given population technique. The rationale behind sampling is that in reality it's difficult to implement census where time and financial constraints are main bottlenecks.

The sample selected from a given population is being a good representative of the population, an entire homogeneity of the population is important. As far because the agro ‘ecology and farming system of the study area cares it is more or less homogenous. Hence, a multi-stage sampling procedure and simple random sampling technique (lottery method) was used to identify sample households for data collection.

For the sample size determination Yamane T. (1967) formula was employed because of the known population. Following the formula, the estimated sample size for a 95 % level of significance is given as follows:

$$n = \frac{N}{1+N(e)2} = 1600/5=320 \quad (10)$$

where, n is number of sample size selected from N, is (1600), total household of red pepper producers in the study area and, e = 0.05, margin of error.

3.3. Sources, Type of Data and Method of Data collection

The study was used both primary and secondary data as sources of information. The primary data necessary for the quantitative analysis that was collected from sample households. The secondary data were gathered from various sources like journals, books, records, and documents of the organizations such as CSA, and other sources.

3.4 Methods of Data Analysis

Both descriptive and econometric methods of analysis were used. The descriptive statistics were used to summarize the row data. The descriptive statistics used in this study include mean, standard deviation, percentage, frequency of occurrence and histogram.

The stochastic frontier analysis is one important model that enables to incorporate random noise effect and to considered heteroscedasticity of technical efficiency between farmers. However, the flexible stochastic frontier model is superior to the deterministic and the conventional stochastic frontier approaches. The advantage of this model as compared to the conventional stochastic frontier model is its ability to incorporate the stochastic noise, inefficiency and production risk effects to analyze technical efficiency (Kumbhakar, 2002).

3.5 Empirical Model Specification

The basic idea of this study is the deviation from frontier output may not only because of technical inefficiency alone, as just indicated by Kumbhakar (2002). But this extended Kumbhakar (2002) production function cannot able to estimate the determinants of the inefficiency factors facing pepper farmers'. Hence, the empirical model was based on the extension of the standard stochastic frontier model which allows accounting heterogeneous risk term as indicated by Kumbhakar *et al.* (2015) and Wang (2002).

The stochastic frontier estimation needs prior functional form specification. Due to this reason, the Cobb-Douglas production function has been chosen to estimate stochastic frontier model. The Cobb-Douglas production function specify as follows:

$$\ln Yi = \beta_0 + \sum_{n=1}^{4} \beta j \ln(Xij) + Vi - Ui \qquad (17)$$

In the above production function, the mean inefficiency and risk terms were assumed heterogeneous, as these terms are a function of exogenous factors. So that, the determinants of the technical inefficiency and the risk factors are captured and investigated by using an alternative stochastic production frontier specification developed by Wang (2002) and Kumbhakar *et al*. (2015). In this restructured stochastic frontier model specification, inefficiency term was assumed to have a linear relationship between its mean inefficiency and determinant factors. The model of the technical inefficiency effects in the stochastic production frontier equation is defined by:

$$\mu i = a_0 + \sum_{n=1}^{11} \alpha ij\, Zui \qquad (18)$$

μ_i, is pre- truncated mean of inefficiency, that is explained by factor variables, $Zu_{,i}$ is Z_1, Z_2… Z_{11} are explanatory variables, which affect mean of inefficiency α, parameter estimators of inefficiency function. Z_1 is age of household head in years (age), Z_2 is educational levels of household head in year of schooling (educ), Z_3 is frequency of household head extension contacts (exten), Z_4 is family size (AE), Z_5 is sex of household head (gender), Z_6 is access to credit (accredit), Z_7 is source of seed (source seed), Z_8 is red pepper disease (Pdis), Z_9 is access to market information (Minfo), Z_{10} is method of red pepper planting, Z_{11} is livestock (livestock)

On other hand, in the above production function the risk function of each red pepper farmers is assumed to be heterogeneous, as a function of input factors. The estimable form of this relationship has gone to the alternative stochastic frontier model. The model of production risk effects in the stochastic production frontier equation is defined as:

$$\sigma vi^2 = \exp\left(\delta_0 + \sum_{k=1}^{4} \delta k \ln Z\, vk \right) \qquad (19)$$

where δ is the estimated parameters of risk model and the V_i is the pure noise effect. The exponential functional form (exp) was assumed between the risk term and its exogenous factors (inputs). This enables to preserve the positive nature of variance. Zvi,k is X_1, X_2, X_3 and X_4 are input factors, which are specified in the risk function. From this input factors X_1, X_2, X_3 and X_4 risk indicating variable inputs which was represented as follows:

$\ln X_1$= natural logarithm of the amount of seed in kilogram

$\ln X_2$ = natural logarithm adult equivalent of labor hours

$\ln X_3$ = natural logarithm agrochemical's measured in milliliter

$\ln X_4$= natural logarithm amount of chemical fertilizers used measured in kilogram

δ is parameter estimators of risk function.

The δ_k, is marginal production risks of the individual inputs and if it is positive it means that the respective input is risk increasing, whereas δn becomes negative it means that respective input is reduces output variance. The input factor such as labor, seed, fertilizer and agrochemicals can either increase production risk or decrease it.

The maximum likelihood estimation approach was used to estimate the stochastic production frontier model. The related Log-Likelihood function combines a mixture of truncated normal distributions defining prior truncated mean inefficiency and the heteroscedastic residual term. The Log-likelihood function of stochastic frontier production estimated using sfcross commands in the STATA16 software.

Once the stochastic production frontier model has been estimated using one step maximum likelihood estimation approach, the technical efficiency scores of each farmer was calculated based on Kumbhakar *et al*. (2015) indicated model.

$$TEi = E\{Exp(-Ui)/\hat{E}i\} \quad (20)$$

where E {.}, is the expectation operator and $\hat{E}i$ is estimated residual term

The risk terms of each farmer that is obtained from the estimated value of the exponential function that is represented by equation 19. It was also possible to estimate the marginal effect of each exogenous factor on mean inefficiency using the procedure suggested by Kumbhakar *et al*., (2015).

RESULT AND DISCUSSIONS

4.1 Hypothesis and Diagnosis Tests

As the results of the hypothesis tested indicated that in table 4.3, the null hypothesis that the Translog is best fit the data set is rejected at 1 per cent level of significance. The Cobb-Douglas form of the model is therefore the best fit for the data. Also show that the null hypotheses which state that there is no inefficiency in the model is rejected at 1 per cent level of significance. This confirms that there is one-sided error term in the red pepper production.

Table 4. 1: Results of Hypothesis Tests

Null hypothesis	Tests Statistics(λ)	Critical value(x^2)	Decision
Ho ; βij=0	13.842***	12.483	H_o Rejected
Ho;δ1=δ2.=0δ4=0	40.046***	12.483	H_o Rejected
$H_{o;}$ λ= 0	198.130***	5.412	H_o Rejected
Ho;θ1=θ2=⋯θ11=0	162.170***	24.049	H_o Rejected

Source: own survey result (2019) *** and ** shows significance level at 1%, and 5%, respectively

The last null hypothesis state that, the specified inefficiency factors and conventional input factors don't have a joint effect on technical inefficiency is rejected by a 1 per cent significant level. The combined effect of both stated input and technical inefficiency factors affect technical efficiency.

The estimated value of lambda (λ=σu/σv) parameter (1.210) that is showing the ratio between the truncated normal positive error and the idiosyncratic error terms, which indicates that the one side error term u dominates the symmetric error v, so the variation of the actual output of red pepper production mainly comes from differences in farmer's practice (mismanagement of farm) rather than random variability. Likewise, this demonstrates the fact that there is significant inefficiencies variation in red pepper production probably caused by differences in socioeconomic characteristics of the households and their management practices. This points out that a goodness of fit specified model and correctness of distributional assumption on both errors term (Aigner *et al*., (1977)).

The parameter gamma lies between zero to one; with a value equal to 0 means that technical inefficiency is not present, and ordinary least square estimation would be an adequate and a value close or equal to one implying that the frontier model is appropriate to estimate the parameters of model (Kumbhakar *et al*.,(2015)). The estimates result of the maximum likelihood for the gamma ($\gamma=\lambda^2/\ \lambda^2 +1$), parameter (explains that around 60 per cent of the variation in the model is caused by technical. This indicates that from the total variation of output in red pepper production, 60 % of the variation is due to inefficiency effects of farmer's specific attributes and rest is due to random error. This means that the major problem for the deviation of output from the potential level is due to the inefficiency.

4.2 The Econometric Model Analysis

To determine the extent of production, the concept of elasticity is important. The response of output as a result of a change in input factors measure the productivity of farm input. The entire change concerning each red pepper input variables shows returns to scale.

The red pepper output elasticities are labor 0.210, fertilizer 0.443, seed 0.114 and agrochemicals 0.286. The findings of this study are in line with the work done by Abate *et al.* (2019) on technical efficiency of smallholder farmers in red pepper production in North Gonder.

The findings of this study provide that highest output elasticity is due to the changes in fertilizer (0.443) and followed by output elasticity is that results from due to the change in quantities of agrochemicals (0.286). The returns to scale may be a summation of all partial derivate of output with respects to all or any inputs. It's wont to check the status of economies of scales. If its value is bigger than one, indicates that there's an increasing return to scales in the long run, in line with (Kumbhakar *et al*., 2015). The estimated return to scale in this study was 1.051. This value is bigger than one, which confirms that the red pepper production technology has increasing returns to scale within the study area.

Table 4. 2 : Elasticity of Production Function and Returns to Scale

Variables	Elasticity
Labor	0.210^{***}
Fertilizers	0.443^{***}
Seed	0.114^{***}
agrochemical	0.286^{***}
RTS	1.051

Source: own survey result (2019)

The results of the linear production risk shows that all input variables were significantly affected production risk except labor. This demonstrates that red pepper output variability affected by type and levels of inputs used in the red pepper production in the study area. This is in line with the work done by Roll and Asche (2006) indicated that farmers try to manage production risk through the input factors.

To stabilize red pepper output, identifying which input factors have production risk increasing and decreasing effect is important. The study revealed that even if statistically not significant labor has risk-increasing effect and fertilizer, seed and quantity of agrochemicals have risk-reducing effect. The results of the study agree with the work done by Lemessa *et al*. (2017), on production risk-adjusted technical efficiency of maize farmers in Ethiopia.

4.6Determinants of technical inefficiency

The result of the inefficiency model demonstrates that there is an inefficiency differential across the sample red pepper farmers. The variables such as education level (college and above) of farmers, age of household head, access to market information, family size, pepper disease, method of planting, sex of household head were significantly affected the technical inefficiency of red pepper producers. The other variables such as farmers' frequency of extension contacts, sources of red pepper seed, education at primary school and secondary school level, access to credit and tropical livestock units were not significant.

The farmer's age has a positive effect on technical inefficiency; as farmers get older they become less efficient. This is due to age increases they're become less active to work and flexible to adopt technologies' with farming activities. This is agreed with the work done by Fatima *et al.* *(*2017). They argue that younger farmers are more efficient than older farmers. However, other empirical study was done by Abate *et al*. (2019) on technical efficiency of smallholder farmer in red pepper production in north Gondar, Ethiopia argued oppositely. Their results confirm that ageing farmers are becoming more experienced that enables to increase the knowledge of best agronomic practices. Hence, this will enhance the technical efficiency.

The parameter estimator's of the gender variable point out that, the household head being a male more efficient than being a female. This result justifies the findings of Dipeolu.A.O and S.O Akinbode (2016) that records household head being a male farmer more efficient than a female farmer. This could be explained by the fact that men have greater access to market information, most likely because of cultural impartiality and religions females stay at home. This decreases their chance of getting information and hence, this will lower efficiency.

The results of this study, demonstrate that family size has a positive relationship with technical inefficiency. This relationship shows, that the larger household size decease the technical efficiency levels of farmers. This is because the larger household not properly employed their family members in farming activities. The households not properly managed their family members' means more members' dependents on a few household members. Hence, become less efficient. This is consistent with the study done by L.B.Adeoye *et al.* (2014) on analysis of technical efficiency of pepper production among farmers under tropical condition. However, contrary to the work done by Lagiso and Geta (2020) that confirm that the larger family size more efficient than smaller family size. The large family size would mean, more family labor will be available for farming activities.

The educational level of household heads is the main exogenous variable which has effect on the technical inefficiency. The estimation results of this study point out that, household heads educational level changes from secondary to college-level their efficiency decrease. This indicates that farmers who have spent many years more than a secondary level of educations are more likely inefficient in red pepper production. This could be attributed to more educated farmers have better access to other employment opportunities. Therefore, they made red pepper production secondary activities and correct management practices like timely planting and weeding, fertilizer applications and diseases follow-up problems we're occurred in the farm.

Access to market information has a negative and statistically significant effect on levels of farmer's technical inefficiency. This implies that as farmer more informed on the input and output price it is expected to make a right decision on their farm and become more efficient than their counterpart. The result contrasts to the findings obtained by Abate *et al*. (2019) that was indicated untimely market information reduce the technical efficiency of farmers.

The parameter estimated for the variable indicating the disease has a negative sign, implying that the technical efficiency diminishes when the farmers face red pepper diseases problems. This finding agrees with work done by Abebo (2019) on technical efficiency of red pepper production and its determinants among smallholder farmers in Shashogo District, Ethiopia. This is maybe due to the facts that prevalence of disease causes the death of red pepper plant and decreases their number on the farm. Hence, this will losses yield and lower technical efficiency of farmers. The results of this study demonstrate that row transplanting method of red pepper has a positive relationship with technical inefficiency. This shows that farmers who used broadcast transplanting method in their red pepper farm is more efficient than that of used row transplanting method farmers. This is because of environmental problem like low moisture, pests and underage labor used problems cause loses of number of plants in the farm.

Table 4. 3: Estimated Parameters of Inefficiency Effects Model

Variables s	Parameters	Estimate	Standards error	P>|z|
Constant	α_0	.2070412	.2198592	0.346
Age	α_{i1}	0.005 *	0.0021	0.021
Gender	α_{i2}	-0.161*** .	0.048	0.001
Family size	α_{i3}	0. 068***	0.012	0.000
Extension	α_{i4}	-0.0016	0.002	0.335
Access to credit	α_{i5}	-0.037	0.040	0.358

Access to market information	α_{i6}	-0.163 ***	0.045	0.000
Methods of planting	α_{i7}	0 .076**	0.037	0.037
Pepper Diseases	α_{i8}	0.175***	0.038	0.000
Livestock	α_{i9}	0.014	0 .020	0.464
Education	α_{i10}	0 | 0 .25		
		1 | 0.0036	0.041	0.931
		2 | -0.058	0.050	0.250
		3 | 0.184 **	0. 0775	0.017
Source of Seed	α_{i11}	-0.015	0 .044	0.728

Source: own survey result (2019) *** and ** shows significance level at 1%, and 5% respectively.

4.3 Production risk and Technical efficiency distribution

The results of this study show that the causes of technical efficiency differentials among red pepper farmers is both technical inefficiency and production risk management ability in the study area. The production risk-adjusted technical efficiency of sample farmers ranged from 16.3 to 94.4 per cent. Most of the sample farmers were concentrated in three classes of efficiency intervals such as 0.27-0.37(27.81), 0.38-0.48(20.94) and 0.49-0.59(20.31) respectively. The least number of farmers were found in between 82 to 94.4 per cent (2.16%) of the technical efficiency interval. Also, the study demonstrates that farmers on average 46.55 per cent efficient in their red pepper farm. This indicates that the farmers producing on average 46.55 per cent of their maximum possible output level, given the state of technologies at their hand. This demonstrates that on average farmers were producing 45.55 per cent below frontier level with the given technologies. This shows that there is a way to increase output by 45.55 per cent on average without changing given technology.

However, in case of technical efficiency estimations without considering the heterogeneity of production risk management strategies shows different results. This confirms that the problem of low-level efficiency is addressed by improving both inefficiency and production risk management abilities of each red pepper farmers. To manage red pepper production risk with inputs, the risk averse farmers use more of risk-reducing inputs and less of risk increasing inputs in the production process. Hence, this production decisions that considered environmental risks, will enforce the farmers to compromise their technical efficiency level. That's why the average technical efficiency of red pepper farmers reduced from 62 to 46.55 per cent. Therefore, on average the red pepper farmers was compromised their technical efficiency by 15.95 per cent in the study area. Furthermore, this study also shows that, the technical efficiency distribution of farmers was concentrated in lower intervals, in the case of production risk-adjusted efficiency estimations'. From sample farmers, most of the farmers (37.81%) efficiency scores were between 71 to 92 per cent. However, on the same technical efficiency interval (71 to 92%), only 10.62 per cent of sample red pepper farmers were achieved in the case of production risk adjustment efficiency estimation. Rather, most of the sample red pepper farmers (48.75%) scores were in the 27 to 48 per cent of efficiency ranges

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study result also showed that the production elasticities of output with respect labor, seed, agrochemicals and fertilizer are positive and summations' of elasticities' is 1.051. Therefore, it is reasonable to conclude the production technologies reflect increasing returns to scales.

The study shows that production risk function jointly affected by stated production inputs. The sign of estimated parameters of seed, agrochemicals and fertilizer indicates that they are risk decreasing and labor was risk increasing input variable. This indicates that there is heterogeneity of risk management strategies and risk effect among red pepper farmers. Hence, this result enables us to conclude that technical efficiency is affected by not only inefficiency variable but also production risk variables.

The results demonstrate that the deviation of output from the frontier was not only as a result of technical inefficiency effect but also the effects of inputs on production risk. The effect of technical inefficiency was greater than that of two-sided error component and the goodness of fits of the stated stochastic frontier model.

Furthermore, most of the farmers are still using their resources inefficiently in the production process. The mean efficiency of red pepper farmers was of 62 per cent. Hence, there is an opportunities for increasing yield by 38 per cent without changing the level of inputs and technologies by operating at a fully efficient level.

However, the mean efficiency was reduced to 46.55 per cent when production risk was adjusted in the study area. Therefore, not considering production risk in inputs, in estimating the efficiency of agricultural production will result biased values of technical efficiency. This enables to conclude that, to manage production risks that related to inputs, farmers were forced to compromise parts of their technical efficiency. Hence, to enhance the productivity of red pepper priority should be given to efficiency improvement issues rather than the introduction of modern technologies. This also implies technical efficiency improvement issues must be synchronized with risk mitigation strategies like farmer’s crop insurance, contractual agreement, subsidize through inputs and others. This enables the farmers to specialize in their production based on agro ecological and market advantage.

The findings of study shows, education levels of household head, ages of household heads, family size, and market information, sex of household heads, red pepper disease, and method of planting are variables that significantly elucidate technical inefficiency levels of farmers.

The educational level of household heads correlated negatively with the technical inefficiency of farmers and it is significant at 5 per cent level. This result shows that farmers who have spent many years in formal education, especially at college level and above are will be more inefficient. This provides insights that as farmers more educated their job opportunities are increases. Hence, this will result share of the time and resources among jobs and even farmers will make red pepper production as secondary income sources. Instead, spend a more on higher education’s strengthen farmers training institutions is more important.

The result of the study also justifies that contact with extension workers has a negative sign, implying that the technical inefficiency diminishes with the number of visits made to the plantation by extension workers. Regular contacts with these workers facilitate the practical use of modern techniques and the adoption of agronomic norms of production.

Furthermore, market information affecting technical inefficiency's negatively at 1 per cent significant level. This demonstrates that accessibility of timely information through the radio and television program, advancement of telecommunication infrastructure will enhance farm productivity. This is because of empowers farmers to make the right decisions. The age of household heads inversely related to technical efficiency. The sex of household head being males is directly related to technical efficiency. This both results indicated that red pepper production needs high labor and works hard. The study findings show that family size has an inverse relationship with technical efficiency. This is able to conclude that large households do not properly manage their labor force.

The study results demonstrated that diseases were negatively correlated with technical efficiency levels of red pepper farmers. This shows that the prevalence of diseases reduced the quality and quantity of red pepper yield in the study area.

The results of this study contributed to the knowledge available summarized as follows. The study findings show quantity of agrochemicals, fertilizers, and quantity of seed reduced production risks of red pepper farmers in the study area. The study also revealed that most of the red pepper farmers were technically inefficient in the study area. The study demonstrates that there was a significant difference between the mean technical efficiency without accounting production risk in inputs and a production risk-adjusted technical efficiency of red pepper farmers in the study area. Moreover, the study identified the determinant of technical inefficiency in the study area.

5.2 Recommendations

Based on the findings of this study, the following policy recommendations are made thus will be able to enhance red pepper output, eradicate technical inefficiencies and manage to the effect of risk in the production process.

The red pepper farmers in the study area should increase the optimal use of inputs such as seed, fertilizer, agrochemicals and labor, since increasing these inputs at optimal rate has the potential to enhance red pepper output. The increase in the usage of inputs can be made possible if the supply of that input is readily available, affordable and accessible to farmers. Hence, the government and NGOs should ensure accessibility of these inputs.

The employment of fertilizer, seed and agrochemicals are risk-reducing inputs. Therefore, extension agents must encourage farmers to appropriately manage these inputs to mitigate the effect of output variability.

The government should focus on the development of telecommunication facilities, rural market centers (institutions), this will able to make the right decision on red pepper production. The information assimilation mechanisms like experience sharing farmer with farmer are important to exploits indigenous knowledge effectively. The government may be better to facilitate the formation of farmers' crop insurance. If farmers have insurance that shares the impact of risk, they can make production decisions confidently. Hence, its effect will enhance the efficiency level of the red pepper farmers.

The study findings also show higher education levels of household heads are negatively related to technical efficiency. Hence, the government should give training to red pepper farmers on current best agronomic practices.

The finding of the study elucidates that diseases negatively affect the technical efficiency of the red pepper farmers. Therefore, the government should encourage the research institutions to do the study on the causes of red pepper diseases in the study area. Furthermore, the government and NGOs better to provide fungicides and pesticides at affordable price.

One of the limitations of this study was unable to estimate technological changes through time intervals in the study area. Therefore, estimation of technical efficiency using panel data with considering production risk is the research gap that able to understand the technical changes in the study area. Furthermore, the substitution of crops and production risks in the input is the other research gap that able to know which crop is optimized the impacts of production risk among available main crops in the study area.

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