Innovations

Economic Efficiency of Turmeric Production: South-Western Ethiopia

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***Abstract**: Turmeric is widely grown in the southwestern region of Ethiopia, specifically in Bench-Sheko and Sheka zones. Nevertheless, different evidence shows in terms of productivity it was not satisfactory. The study aimed towards estimating allocative and economic efficiency levels, to detect factors affecting allocative and economic efficiency in Sheko and Yeki districts. To conduct this research, the data were collected from 360 sample turmeric producers. Cobb-Douglas and Tobit models were used to analyze efficiency and determinate correspondingly. Accordingly, the average allocative and economic efficiencies were 60.78% and 44.71, correspondingly. Average allocative efficiency implies a prospect to decrease the cost of inputs by 39.22%. Turmeric yield was certainly and meaningfully affected by area worker oxen seed, chemicals plus urea. Tobit regression outcome showed economic efficiency was absolutely and meaningfully influenced by the extension agent interaction, credit utilization, and market information. Strategies focus to inspire and increase the delivery of credit, support the present farm extension structure, and provide relevant marketing information needed to expand the economic efficiency of turmeric.*

***Keywords**: 1.conomic efficiency, 2.Frontier, 3.Tobit, 4.Turmeric*

1. Introduction

Turmeric is a well-known spice and medicinal plant, obtained from the underground rhizome of *Curcuma longa* (Family -Zingiberaceae). Used as a food coloring agent as well as a coloring material in the textile industry (Mahmood et al. 2015).

The SNNPR is accountable for 76% of Ethiopia's turmeric production (Mekonnen and Garedew 2019). Backward cultivation practices and techniques, absence of turmeric agricultural research, irregular supply and variable quality of turmeric produced, weak business linkage, absence of microlevel support organizations, raising the contribution of uninhibited agents in the exchange of turmeric in the market, fragile selling arrangement, absence of planned market data provision to the diverse performers in the turmeric are the main problems these hinder turmeric productivity (Tesfa et al. 2017).

Thus, production inefficiency can be reduced through increasing farm output by increasing productivity (Kumbhakar and Lovell, 2008, Fried, 2008). The yield of turmeric in Ethiopia is still low (24qt/ha) as associated with India (40qt/ha (Addisu 2014). This yield gap might be a result of numerous causes (Lupi and Temteme 2015). In this regard, it is necessary to identify the factors of production and enumerate the existing levels of economic efficiency of turmeric production in the Sheko and Yaki districts.

2. Method

Bench-Sheko and Sheka zones were the study sites, these districts were found in the newly established southwestern Region. The figure below shows the location of these two districts.

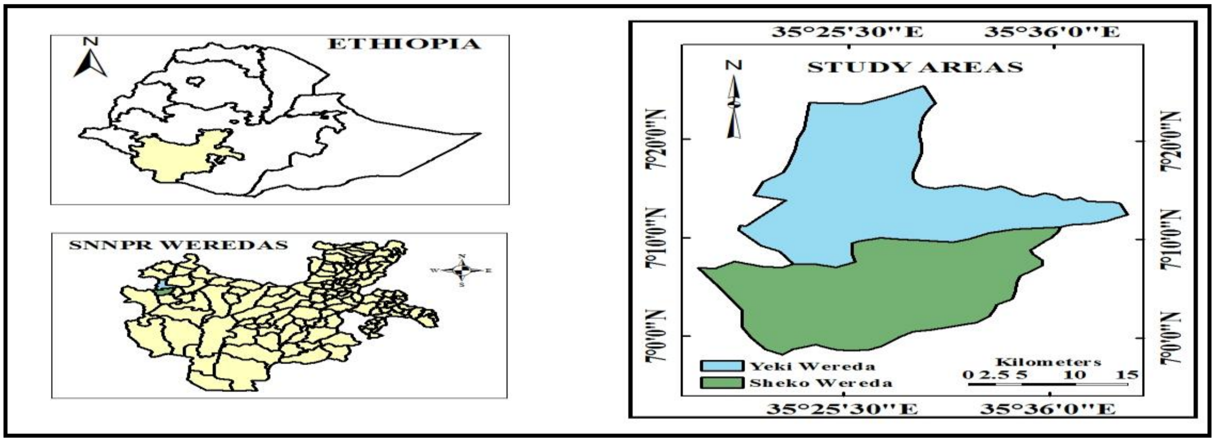

Figure 1: Diagram of Yeki and Sheko Zones

2.1. Source, Type, and data collection Method

To analyze the economic efficiency of turmeric production in two zones, qualitative and quantitative data types were collected. A primary figure was collected from the farmer through personal interviews using a semi structured questionnaire. In addition, FGD and key informant discussions were employed with DA, model farmers, agricultural office leaders, and some selected household heads (HH) who who have experience in turmeric production.

The secondary sources of data related to turmeric production were collected from important journals, books, project baseline survey reports (like MoARD, CSA, FAO) conducted in recent times, and the agriculture and natural resource development office of the two zones.

2.2. Sample method and sample size determination

Bench-Sheko and Sheka zones were selected purposively. From Bench-Sheko and Sheka zones, Sheko and Yeki districts were selected purposively based on the study objectives, respectively. In the Sheko district, from the total of 24kebeles, *and 10 kebeles*are turmeric producers and in the Yeki district there are 22 *kebeles* from these 20 *kebeles* are turmeric producers. In the first stage from total turmeric producer *kebeles*, two from Sheko and four from Yeki district were selected randomly. In the next phase, an entire 360 turmeric producer HHs were selected randomly using PPS of HHs in each selected *kebele*(table1). (Yamane 1967) formula was used to fix the sample size.

Table 1: Distribution of sample farmers across sample sites

Zones	Districts	Name of sample	Household heads	Sample size by PPS
Bench-Sheko	Sheko	Gizmeret	345	35
		Shemi	268	27
Sheka	Yeki	Hibretfrie	704	71
		Beqa	440	44
		Bechi	931	94
		Shosha	879	89
	Total		3,567	360

Source: YDAO and SDAO (2020)

2.3. Methods of data analysis

The stochastic frontier method was used in this study. Since the uncertainty of agricultural output (Moutinho*et al.*, 2018). The stochastic model on behalf of this study specified as follows (Meeusen and van Den Broeck 1977),

$$y_i = f(X_i.\beta) + \varepsilon_i \qquad 1$$

Where: - y_i =output of turmeric, X_i= vector,f( ) = suitable formula, β =unidentified production constraints,ε_i = collected fault term ($V_i$and U_i).

Cobb-Douglas is commonly applied in frontier production function research (Sarker and De 2004). For this study, based on the results of the GLR test, this functional form was used.

This model estimated is given by:

$$Y_i = \beta_o * \prod_{i=1}^{n} X_i^{\beta_i} * e^{(V_i} - U_i) \qquad 1.1$$

The value of the GLR statistic to examination the assumption that all collaboration terms comprising the square root specification are equal to zero (H0 = β_{ij} = 0) was calculated as follows:

LR=-2[L(T*l*)-L(CD) 1.2

According to Arega and Rashid (2006), the cost is derived systematically from the production function as follows.

$$Min \sum_{x} C = \sum_{j=1}^{6} X_J W_J \qquad 1.3$$

Subject to $Y_i^* = \hat{A} \Pi X_i^{\hat{B}_j}$

Wher $\hat{A}$ = exp ($\hat{B}_0$)

ω_J=input prices

$\hat{B}_0$= Constraint evaluation stochastic production,

Y_i^*=input-oriented production

The next double cost function is established by replacing the cost reduction input in to calculation 1.4.

$$C(Y_k^{i^*}, w) = HY_k^{i^*\mu} \Pi_n \qquad 1.4$$

$$\alpha_n = \mu \hat{B}_{\mathrm{n}}^{}, \mu = (\Sigma_n \hat{B}_{n),}^{-1} H = \frac{1}{\mu}(\hat{A} \Pi_n \hat{B}_{n)}^{\beta_{n-\mu}} \quad 1.5$$

Economic efficiency for the sample grower is obtained using Shepard's Lemma and replacing the company's input fee and output with input demand equations as indicated below.

$$\frac{\alpha C_i}{\alpha \omega_n} = X_i^e\left(\omega_i Y_i^{i^*}; \theta\right) \quad 1.6$$

Where ϴ= vector of constraints and n = inputs.

Cost efficiency is the proportion of practical overall cost (C*) to the real overall output fee (C).

$$\frac{C^*}{C} \quad 1.7$$

According to Farrell (1957), the AE can be generated as 1/CE and since economic efficiency is an interaction effect of technical and allocative efficiency, it can be calculated as follow,

$$TE * AE = EE \quad 1.8$$

The Tobit model was used to detect factors affecting economic efficiency. According to (Maddala 1986)the model is a better fit for this investigation since the characteristics of the dependent variable between zero and one provide reliable guesses for the indefinite parameter. Two-limit Tobit model can be stated in this form (Maddala 1986).

$$Y_{i\,(TE,AE,EE)}^* = \delta_0 + \sum_{j=1}^{10} \delta_j{}' \, X_{jK} + \mu_i \quad 1.9$$

Where Y_i^* efficiency scores,δ_0,δ_1 , … , δ_{10}=constraints,X_j different determinants, μ_i= an error term. Efficiency scores for turmeric farmers range between zero and one. This model can be defined as,

$$Y_i = \begin{cases} 1, if Y_i^* \geq 1 \\ Y_i^* \; if \; 0 < Y_i^* < 1 \\ 0, if Y_i^* \leq 0 \end{cases} \quad 2$$

3. Result

As indicated below in (table2), the result of descriptive statistics is presented to create a general image of the study area.

Table 2: Descriptive analysis results of continuous and dummy explanatory variables

Variables	Mean	Std. Deviation	Min	Max
Age of HH	46.33	12.50	27	78
Household size	5.57	3.7	2	13
Household size (Man-equivalent)	4.95	2.70	1.41	8.9
Frequency of extension contact	1.25	0.45	0	3
Land fragmentation (No of plots)	2.16	1.011	1	4
Credit utilization	441.81	1775.28	0	17000
Livestock ownership (TLU)	3.58	2.38	0	15.25
	Number of Household heads		**Percent**	
Sex	Male	303	84.17	

	Female	57	15.83
Market information	Yes	48	13.33
	No	312	88.67

Source: own survey (2020/21)

On average, sample households produced 25.36 Qt of turmeric. The area assigned for turmeric production by sample farmers throughout the study season fluctuated from 0.25 to 8 ha through a mean of 1.52 ha (table 3)

Table 3: Overall results of input variables employed in turmeric output and cost function

Variables	**Unit**	**Mean**	**Std. Deviation**	**Mini**	**Max**
Output	Quintal	25.36	14.80	10	250
Labor	Man-day	131.51	62.70	40.8	291.80
Land	Hectare	1.52	1.70	0.25	8
Urea	Kilogram	10.93	19.80	0	75
Seed	Kilogram	635.64	378.80	55	3000
Herbicide	Liter	0.76	1.01	0	4.5
Oxen power	Pair of oxen days	4.32	2.47	1	14
Cost item			**Percent**	**Std. Deviation**	
Cost of output	Birr	13912.5	-	9650.18	
Cost of land	Birr	6849.22	21.93	7656.21	
Cost of labor	Birr	9205.42	29.47	4389.02	
Cost of oxen	Birr	1752.36	5.61	1023.58	
Cost of urea	Birr	8089.65	25.90	14655.45	
Cost of seed	Birr	5072.44	16.24	3009.95	
Cost of herbicide	Birr	267.25	0.86	353.72	

3.1. Econometric results

Table 4 indicates the result of the hypothesis related to selecting the correct functional form and detecting the inefficiency.

Table 4: The result of GLR test

Hypothesis	**LH_0**	**LH_1**	**Calculated X^2 (LR) value**	**Critical value ($\chi 2$, 0.95)**	**Decision**
H0: = β_{ij} = 0	-204.46	-221.77	34.62	40.11	Accept
H0: = δ_1 = δ_2 ... = δ_{10} =0	-221.77	-181.96	79.62	16.92	Reject Ho

Estimation of production function

Among the input variables, oxen power has high responsiveness for turmeric output (0.281), indicating that turmeric output was fairly delicate to oxen power. Thus, a 1 % rise in the quantity of oxen power in a pair of oxen days resulted in a 0.281% increase in output.

Table 5: Results of Maximum likelihood Estimation

Ln Output	Coefficients	Std. Err.
Cons	1.447***	0.302
LN Seed	.131**	0.054
LN Land	.243***	0.036
LN Oxen power	.281***	0.055
LN Labor	.243***	0.059
LN Urea	.015***	0.005
LN Herbicide	.032***	0.008
Sigma v	.3706197	.0326548
Sigma u	.4222391	.0801498
sigma2	.316***	0.050
Lambda	1.139	0.108
Log-likelihood function	-221.77	
Return to scale	0.945	

Survey Result (2020/21)

Efficiency scores of sample farmers

Table 6: Descriptive statistics of efficiency scores

Types	Mean	Std. Deviation	Minimum	Maximum
AE	60.78	.1345	19.88	86.69
EE	44.71	.1135	14.82	75.45

The distribution of economic efficiency scores suggests that about 34.17% of the sample households were carrying out below average efficiency levels (figure 2). 35.83% of turmeric producers worked between 41% and 50%. Farmers in this cluster can save a minimum of 50% of their present cost of factors of production by acting in a cost-reducing technique.

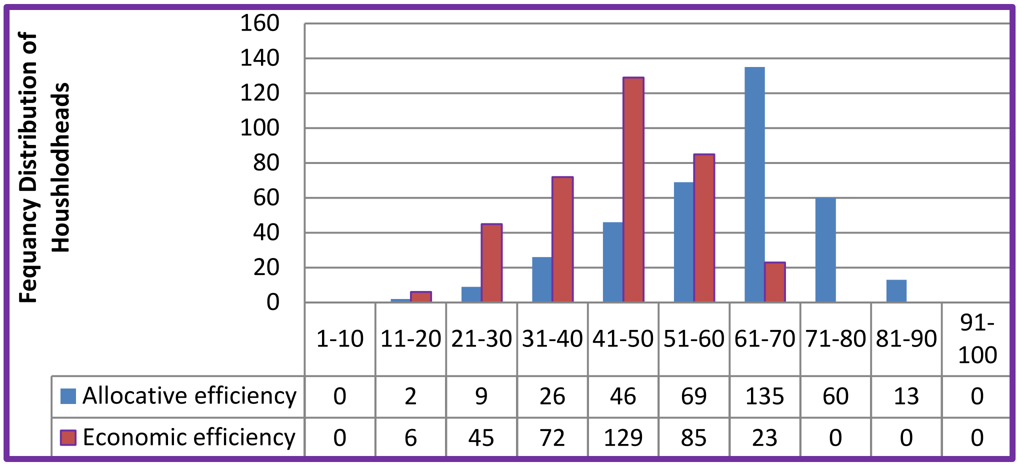

Figure 2: Frequency chart of AE and EE score

Determinants of AE and EE in Turmeric Production

Table 7:Two-limit Tobit estimation result of explanatory variables

Variables	Allocative efficiency		Economic efficiency	
	Coef. (Std. Err.)	ME$[\partial(\varphi(Z_U) - \varphi(Z_L)$	Coef. (Std. Err.)	ME $[\partial(\varphi(Z_U) - \varphi(Z_L)$
SEX	0.0162 (0.019)	0.0048	-0.007 (0.016)	-0.0000
AGE	-0.001* (0.001)	-0.0004	0.000 (0.001)	3.62e-06
Education	-0.004 (0.002)	-0.0012	-0.001 (0.002)	-0.0000
NOFIC	0.067 (0.712)	0.000	0.002 (0.103)	0.0001
Household Size	-0.001 (0.002)	-0.0003	0.001 (0.001)	8.76e-06
No. plots	-0.007 (0.007)	-0.0022	-0.013** (0.0052)	-0.0001
Extension	0.031** (0.015)	0.0091	0.021* (0.013)	0.0005
Livestock	0.003 (0.014)	0.0129	0.031 (0.091)	0.0001
Ln credit	0.009*** (0.002)	0.0031	0.007*** (0.001)	0.0001
MKT info	-0.006 (0.019)	-0.0019	0.036** (0.016)	0.0018

According to the result of two -limit Tobit model presented in (table 7), the explanatory variables that were hypothesized to determine economic efficiency were discussed as follows: **Age of household head:** Based on the estimation of Tobit model, age had negative and significant at 10% significant level of AE in Table 7. This result shows that as age HH increases, their labor force influence for farming reduce, as a result their AE also declines. The marginal effect of age on AE shows that one-year increase in age leads to a decline in the probability of being alloctively efficiency by 0.04 %. The result was in line with(Baloi 2011; Bealu, Endrias, and Tadesse 2013).

Land Fragmentation (LFRG): The coefficient for several plots revealed the negative impact of land fragmentation on turmeric production, which is significant at a 5% significant level on the economic efficiency of turmeric production. The marginal effect result also confirmed that one unit rises in the number of plots the effect of the fall probability of being economically efficient by 0.01%. This might be due to the fact that disjointed lands contribute to inefficiency by making the scarcity of family labor depletion of time. This finding is confirmed with (Bati, Mulugeta Tilahun, and Parabathina 2017) result.

Frequency of extension contact: This is another important determinate of allocative and economic efficiency. As indicated in Table 7 above, extension interactions had positive association with AE and EE at 5 and 10%, correspondingly. Consequently, the assistance of the extension agent upturns the turmeric yield by increasing the level of AE and EE. Besides, the ME results in Table 7 that a rise in the rate of extension interaction resulted in to rise in the probability fall under AE and EE by 0.91and .05%, respectively. This result is corresponding with (ILONA 2019) and opposing to (Mulatu 2019).

Credit utilization (CRUT): The estimated coefficient of credit associated with turmeric production had a significant effect on AE and EE at1%. This might be, the availability of credit for the resource-poor farmer is important to finance the turmeric production activities. Moreover, the result from ME indicates that the utilization of credit increases by one unit, the probability being allocativelly and economically efficiency increase by 0.31and 0.01%, respectively. This finding is similar to (Abate, Dessie, and Mekie 2019)

Market information (MKT): It had a positive effect on EE of turmeric production was access to market information**.** This result points out, the availability of market statistics had a significant impact on EE at1and 5% significant level. Furthermore, the ME result also indicates that a one-unit upturn in market information would affect raising the probability of the producers being economically efficient by 0.18%, respectively. This was similar to the (Mulatu 2019) finding, who has conducted a study on the determinants of turmeric producers' market outlet choice in Sheka and Majang Zones of the southwest of Ethiopia.

4. Conclusion

The following important conclusions were emanating from the economic efficiency of turmeric production. The average AE and EE of turmeric producer producers were 60.78 and 44.71%, consecutively. These imply that households can diminish the present cost of inputs by 39.22% through the cost reduction technique and there is a possibility to expand EE by 65.29% if growers work at complete efficiency.

Crucial determinants were recognized towards supporting diverse participants to raise the existing levels of efficiency in turmeric production. Extension interaction and credit utilization had a positive and important influence on allocative efficiency. These indicate households who have more extension contact with development agents and use credit for turmeric production were more allocatively efficient than others.

However, the age of the household had, takes a negative influence on AE. It can be concluded that HH with old age allocatively less efficient than these younger ones.
The frequency of extension interaction, credit, and market information had a positive outcome on economic efficiency as estimated. Based on this, it could be concluded that farmers who had more extension contacts, used credit for turmeric cultivation and households with more extension contact were economically more efficient than their counterparts. However, the number of plots that a farmer had an adverse and substantial outcome on EE. Thus, farmers who had more plots were economically less effacement.

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Authors' Contribution
Both authors equally contribute to accomplish this study.

Disclosure statement

The author(s) declare(s) that there are no conflicts of interest regarding the publication of this paper.

Novelty Statement

The novelty of our work entitled "**Economic efficiency of turmeric production: south-western Ethiopia"** different from the previous study that it measures determinant and efficiency level of economic and allocation efficiency of turmeric production. There is no study done on economic and allocative efficiency in the study areas. Moreover in that particular area most of the study focus on marketing, value chain and production constraint using descriptive statistic method. But our study used two limit tobit and stochastic frontier model to clearly identify the production constraints and efficiency level.

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