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Research Article

Analysis of Determinants of Economic Efficiency in Honey Production in Horo Guduru Zone, Ethiopia: Stochastic Dual Cost Frontier Model Approach

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Honey production is generating employment and source of income in the rural area of Ethiopia. However, its productivity was low. The objective of this study was to measure the economic efficiency of honey production in Ethiopia's Horo Guduru Wollega Zone and their limiting factors. To achieve the above-mentioned objective, the study employed a survey methodology using a structured questionnaire tool, and the data were collected from 396 households. Both descriptive and econometric data analysis methods are employed. Dual cost was used to measure the levels of economic efficiency and the Tobit model to identify the determinants of economic efficiency in the study area. In this regard, the analysis relied on a cross-sectional data collected from 396 sample farm households. The mean economic efficiency was 44%. This demonstrates that the farmers in the study area have to decrease production cost by 56% to achieve 100% economic efficiency level. From the determinants of economic efficiency family size, extension services, training, beekeeping experience, and family size are significant technical efficiency variables for honey producers. The study suggests policies to address economic inefficiencies by increasing the number of hives, extending the best performers' experience by increasing the frequency of extension contacts on honey production, facilitating and expanding credit service in the study area, making bee forage access simple, and increasing forest coverage on the land area in line with the current policy of Ethiopia. Additionally, since farmers in the study area spend their time guarding the honey from damage by ants and monkeys, labor that utilizes technology must be made available in the study area.

1. Introduction

Beekeeping is one of the agricultural activities, which is the maintenance of honeybee colonies, commonly in hives for the production of honey and other purposes [1]. Because it may complement household incomes, food, and healthcare, beekeeping is seen as a key element of sub-Saharan Africa's livelihood diversification [2]. Ethiopia is known for its tremendous variation of agro-climatic conditions and biodiversity that favored the existence of diversified honeybee flora and huge number of honeybee colonies [3, 4]. Organic honey products are interesting in this respect due to the sustainable nature of production, their premium prices, and the growing demand for organic products worldwide [5]. Ethiopia's reputation as a country with abundant apicultural resources is due in part to the high number of native farmers and other people who have been involved in the growth and administration of apiculture for many generations [6]. This is primarily due to its flora supporting foraging bees, the presence of a large quantity of honeybee population, ample fresh water, suitable weather and geographical features, and the presence of a large number of native farmers and others engaged in the development and management of apiculture for many centuries which have contributed to Ethiopia's fame in [7].

Beekeeping is a sustainable and high-potential activity for local communities and especially for the rural poor to gain additional income through nontimber forest products, does not require much land or high starting costs, maintains biodiversity, and increases crop yields [6]. Substantial benefits for food production and environmental performance are possible through closing yield gaps, without the need for new technology [8]. In the future, we believe Ethiopia's honey industry will be a sustainable source of income, helping families escape poverty and promoting ecosystem balance and land restoration for the benefit of present and future generations [9]. Average total, net return, and return on investment all increase with increased production capacity [10]. Agro-chemical poisoning, a shortage of bee food, a lack of rainfall, pests and predators, absconding, and a lack of honey storage facilities were other factors that restricted the latent potential of beekeeping [11].

Nowadays, beekeeping is commonly regarded as a sustainable and high-potential activity for rural communities seeking additional income from nontimber forest products. The relative poverty in rural regions can be reduced through the contribution of agricultural factor endowment [12]. As a result, there is low productivity, which lowers the country's contribution to its agricultural GNP. In order to increase productivity, honey producers' economic efficiency must be improved. Most empirical studies [13–16] concentrated on the efficiency of crops. There was little information available on economic efficiency in the honey production. Therefore, this work closes this gap in the literature. The objective of this study is to fill the information and knowledge gap in the study area by analyzing the determinants of economic efficiency performance.

2. Literature Review

Efficiency measurements must be based on well-specified theoretical concepts to ensure correct interpretations for economic policy [17]. It is concerned with the relationship between resource inputs (costs, in the form of labor, capital, or equipment) [18]. Why the interest in measuring efficiency and productivity? I can think of two reasons. First of all, they are success indicators and performance measures, by which production units are evaluated. Second, only by measuring efficiency and productivity, and separating their effects from the effects of the production environment, can we explore hypotheses concerning the sources of efficiency or productivity differentials [19]? Sustainable development can be reflected by various economic, social, and environmental factors that are closely interconnected with each other, and with the additional dimension of time, which stresses the long-term perspective of several factors that require improvement in productive efficiency [20]. Efficiency improvement of existing market-available technologies, systems, processes, or specific components has become a necessity to be able to reach general sustainability goals for different cases [21]. The process of improving productivity is ongoing. The production function, which describes the correlation between visible inputs and output, is the standard tool economists use to assess farm efficiency. We determine technical efficiency levels by defining a production frontier from a certain production function. It is measured as the ratio of the unit's output to the greatest practicable output; a production frontier displays the highest output that may be attained under various input combinations [22]. To boost the productivity and efficiency of honey production, farmers' socioeconomic, agricultural, and institutional qualities must all be improved [10].

Figure 1 in the text below shows this conceptual framework.

3. Methodology

3.1. Description of Study Area. There are 18 administrative zones in Oromia National Regional State, and one of them is the Horo Guduru Wollega zone which far 310 kilometers from Addis Abeba. There are nine districts for administration. The Central Statistical Agency [23] population and housing census indicate that there are 576,737 people living in the zone, 50.1% of whom are men, and 49.9% of whom are women. The zone's rural parts are home to about 89% of its residents. 712, 766.22 hectares make up the entire zone. In terms of agroecology, highlands make up 37.89%, mid-highlands make up 54.75%, and lowlands make up 7.86%. The agricultural system in the Horo Guduru Wollega zone is predominantly a mixed crop-livestock production system. Before collecting the data, permission from the Wollega University Research and innovation director was obtained. However, owing to the country's political circumstances in general and the research area in particular, a written agreement was not permitted.

3.2. Sampling Methods and Sample Size. In this particular study, a multistage sampling procedure was employed to select pilot districts, kebeles, and households. In this regard, out of the 11 districts in the Zone, Guduru, Abe Dongoro, and Amuru were purposefully chosen for the first stage based on the production potential, and from each district, two kebeles were chosen for the second phase. Lastly, 396 sample households were selected using the simple random technique from each of the selected kebeles with a probability proportional to sample size. The sample size was determined based on the following formula given by [24].

$$n = \frac{N}{1 + \left(e^2\right)N}, \tag{1}$$

where n is sample size, N is number of households in the Zone which is 37161, and e is the desired level of precision. This is taken to be 5%.

3.3. Research Design and Data Collection. This study was undertaken in Horo Guduru Wollega Zone, Ethiopia. Particularly, the study was conducted in Guduru, Abe Dongoro, and Amuru districts of the Zone. The three district areas commonly have ample potential for honey production as it is witnessed by farmers' ownership of a large number of hive. In addition, farmers are also nowadays engaged in the production of honey as means of livelihood. The study employed a quantitative approach and cross-sectional

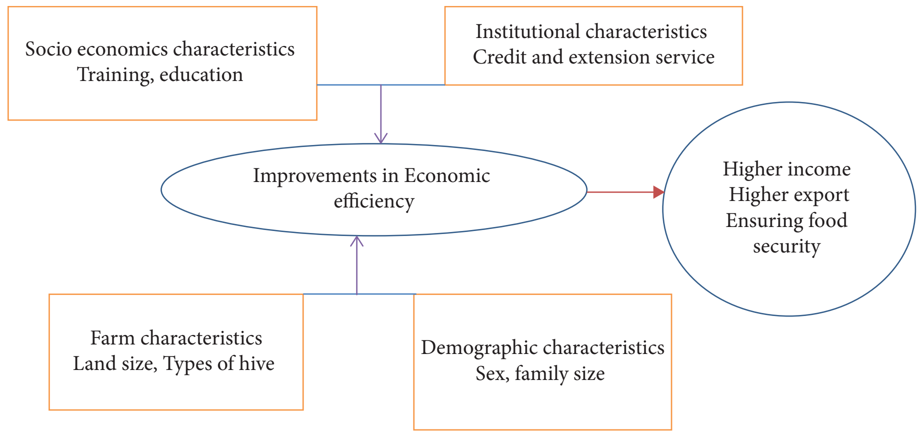

Figure 1: Conceptual framework of the study source: own design.

survey design. Quantitative techniques rely on collecting data that are numerically based and amenable to such analytical methods as statistical correlations, often in relation to hypothesis testing. Cross-sectional survey design was used for its advantage of measuring current attitudes or practices. It also provides information in a short amount of time, such as the time required for administering the survey and collecting the information.

3.4. Specification of an Econometric Model for Estimating Technical Efficiency Levels. The production function was estimated through an alternative form, called dual function. The dual cost function of the Cobb–Douglas production function can be specified as follows:

$$\ln C_i = \beta_0 + \sum_{i=1}^{n} \left(\alpha_j \ln w_j + a_j \ln Y * \right), \quad (2)$$

where i refers to the i^{th} sample farmer; j is number of input; Ci is the minimum cost of production; Wj denotes input prices; Y^* refers to farm output which is adjusted for noise vi; α's parameters were estimated.

Sharma and Patterson [25] suggest that the corresponding dual cost frontier of the Cobb–Douglas production functional form in equation (2) can be rewritten as follows:

$$Ci = C\left(Wi, Yi^*, \alpha\right), \quad (3)$$

where i refers to the i^{th} sample household; Ci is the minimum cost of production; Wi denotes input prices; Y^* refers to farm output which is adjusted for noise; V_i and $\alpha' s$ are parameters to be estimated. The economically efficient input vector of the i^{th} household X_{ie} is derived by substituting the firms' input prices and adjusted output level, and a system of minimum cost input demand equation can be expressed as follows:

$$\frac{\partial ci}{\partial wn} = x^e \left(Wi, Yi, \alpha\right), \quad (4)$$

where n is the number of inputs used. were $wi =$ (cost of number of hive) + (cost of total labor used) + cost of land size

To estimate determinants of economic efficiency in honey production in the study area, the Tobit model was used which was specified as follows. Tobit models [26] belong to a class of econometric techniques traditionally regarded as censored regression models [27].

$$y^{**} = X^{'}\beta + \varepsilon, \quad (5)$$

where y is the observed variable of interest, and y^* is the latent variable. Equation (1) states three things. First, the expected effect of X on y^* is monotonic. Second, the residuals follow a normal distribution. Third, the dependent variable is left-censored and right-censored. The definition of variables and hypothesis was stated as follows (Table 1):

$x_1 =$ Types of hive (1 if modern and transitional hive, zero if traditional hive)

$x_2 =$ Educational levels in year of schooling of household heads

$x_3 =$ Family size (the number of households)

$x_4 =$ Extension contact (the number of contacts received for honey production in a year)

$x_5 =$ Training on beekeeping activities (1 if received training and 0 if not)

$x_6 =$ Experience in beekeeping (year of experience of household in beekeeping)

$x_7 =$ Distance from the market (the distance of beekeeper from the market in minute)

$x_8 =$ Credit uses of household (one if beekeeper receives credit and zero if not)

$\beta =$ is an $(mx1)$ vector of the unknown parameter to be estimated, and

$e =$ is error term in which unobservable random variables are assumed to be independently distributed

4. Results and Discussion

4.1. Descriptive Statics Result. Results of descriptive statics include demographic and socio-economic and institutional services that were discussed as follows.

Table 1: Expected sign of variables.

Variables		Measurement unit	Sign
Dependent variable	Honey output cost		
Independent variable	Total cost number of hive	Number	+
	Total cost of labor for honey production	Man-day	+
	Total cost of land owned by the households	Hectare	+
Variables			
Sex of honey producers		Dummy	+ (if male)
Age of honey producers		Year	+
Education levels of honey producers		Year of schooling	+
Family size of honey producers		ME	+
Access to extension contact		Dummy	+ (if contact)
Access to training		Dummy	+ (if get training)
Honey production experience		Year	+
Distance to nearest market		Minute	−
Access to credit		Dummy	+

4.1.1. Demographic and Socio-Economic Feature of Sample Households. The results of descriptive statistics shows that the average experience of the farmers were 38.25 years old with minimum of 23 years and maximum of 76 year. The household size plays an important role in maize production. The results show that the average household size is 3.48 (Table 2).

Most of the sampled household heads had low levels of education. The mean levels of education of household in the study area were 5.040 with the minimum and maximum of 0 to 12, respectively (Table 2).

Table 2: Socio-economic feature of sample households.

Variables	Mean	Standard deviation	Minimum	Maximum
Experience	38.25	12.77	23	76
Household size	3.48	1.463	0	7
Educational	5.040	3.96	0	12

Source: computed from survey data.

4.1.2. Gender of the Household Head. Overall, the majority of the households surveyed in the region were male-headed with less than a quarter of the total sampled population being female-headed as shown in Table 3. Specifically, approximately 30.81% of the households were female, and 69.19% in the study area were male-headed households.

Table 3: Gender of the household head.

Variables	Frequency	Percentage
Female	122	30.81
Male	274	69.19
Total	396	100

Source: computed from survey data.

4.1.3. Institutional Support. There exist both formal and informal lending institutions to provide credit in the study area. The result shows that 58.33 percent of the household received the credit, and 41.67 percent of the household has not received any credit. Market is one of the basic institutions for the purchase of different farm inputs and to sell their outputs. The mean distances of the nearest market to the farmers were 34.42 minutes and are ranging between 1 minute and 120 minutes. The result of descriptive statics also shows that 59.34 percent of sample farmers received extension contact while 40.66 percent of sample households do not have any extension service on honey production (Table 4).

Table 4: Institutional characteristics of the sample household.

Variables	Response	Frequency	Percent	
Extension contact	Yes	235	59.34	
	No	161	40.66	
Credit	Yes	165	58.33	
	No	231	41.67	
	Minimum	Maximum	Mean	Std. deviation
Distance to the market	1	120	34.42	1.75

Source: computed from survey data.

4.2. Ranges of Economic Efficiency of Honey Production in the Study Area. The predicted economic efficiency ranges between 0.2 and 0.9895962 with the mean economic efficiency of 0.44. In order to give a better indication of the distribution of the economic efficiency, a frequency distribution of the predicted economic efficiency is presented in Figure 2. The frequencies of occurrence of the predicted economic efficiency in decile ranges indicate that the highest number of honey farmers has economic efficiency less than 30%. The sample frequency distribution indicates a clustering of economic efficiencies in the region 0.31–0.50 efficiency ranges, representing 14.89 percent of the respondents. Only 6.06 are above 90%. This implies that the farmers are less efficient in producing a predetermined quantity of honey at a minimum cost for a given level of technology (Figure 2).

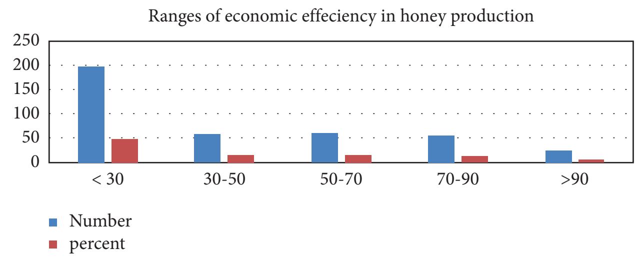

Figure 2: Ranges of economic efficiency in honey production. Source: computed from the model result.

Table 5: Tobit model result for determinants of economic efficiency.

Variables	Coefficient	Standard. error	*T*-value	*P*-value
Types of hive	0.0149831	0.0178872	0.84	0.403
Educational of household heads	0.0036546***	0.0013699	2.67	0.008
Family size	−0.0069402***	0.0024653	−2.82	−0.005
Extension service	0.0003697	0.0167123	0.02	0.982
Training on beekeeping activities	0.0001115***	0.0107958	0.01	0.992
Experience in beekeeping	0.00085**	0.0004658	1.82	0.069
Distance from the market	−0.0004293*	0.0002555	−1.68	0.094
Credit service of household	−0.0126339	0.0111092	−1.14	0.256
Constant	0.2616542	0.0306121	8.55	0.001
Log likelihood = 316.95057		Pseudo $R2 = -0.0501$, number of observation = 396, prob > chi2 = 0.0002		

Source: result of Tobit model. *, **, and *** show the significance at 10%, 5%, and 1%.

4.3. Determinant of Economic Efficiency. Based on the estimated parameter resulted from the Tobit regression model, the influencing factors impact on production, and their respective signs were identified. The positive or negative signs indicated the effects of each explanatory variable on the scores' economic efficiency of honey production (Table 5). Therefore, those variables with a higher impact value should be given an attention in order to improve the existing efficiency level of honey production in Horo Guduru Wollega Zone, and the results of the variables are presented as follows.

The coefficient of experience of the household is statistically significant at 5% level of significance (Table 5). The positive sign for experience indicates that experienced honey-producer farmers tend to be more economically efficient than the no experience farmers. This is due to the reason that farmers with many years of experience in honey production had opportunities that bring the accumulated knowledgethat would improve honey production. This result is in line with [28]. We observed that education has a positive impact on honey production's economic efficiency at 1% levels of significance (Table 5). This is because formal education equips students with the skills necessary to effectively organize production around finite resources and reduce the risk of input loss. Additionally, farmers with the education needed to acquire, understand, and judge data on various inputs, outputs, and market opportunities considerably more quickly than farmers without education. Education is anticipated to have a good impact on productivity. The findings of [29, 30] that more years of formal education increase farmers' level of economic efficiency agree with the positive relationship between education and economic efficiency of honey production. At 1% levels of significance, training has an impact on smallholder farmers' economic efficiency. This demonstrates that farmers who receive training in honey production are more productive economically than those who do not. This is because training improves one's capacity for producing honey and one's ability to use input effectively. Yang and Chen [31] studies add support to this study. The study's definition of family size as the total number of family members had a negative sign demonstrates that farmers with smaller families are more technically productive than those with larger families. This may be the case when a small family can manage challenges with home expenses that are incurred when purchasing inputs for the production of honey. According to the [32, 33] study, there is a negative relationship between family size and economic efficiency which agree with this study. The coefficient of distance to the market was negative based on the finding of the study at 10% level of significance. This was due to the reason that farmers in the remote area face the transportation problem; hence, they face the problem of addition high cost, and they do not get market information on time about inputs' price that determines economic uses of inputs. These results were consistence with the findings of [4].

5. Conclusion and Policy Implication

Economic efficiency has continued to be a crucial area of empirical research, particularly in developing economies where most farmers are resource-constrained. In the Horo Guduru Wollega region of Oromia National Regional State, the technical effectiveness of beekeepers was examined, as well as the factors that contribute to variations in economic efficiency. Detailed information about the production of honey was requested from 396 farmers. The level of economic efficiency of honey producers was examined, as well as the causes of differences in technical efficiency among them. The findings of the estimated stochastic cost production frontier model show that the mean economic efficiency 44% shows that beekeepers might cut their inputs' cost by 56% based on the mean economic efficiency that was provided. Regarding elements that affect economic efficiency, the following guidance was given. First, the government must supply contemporary hives for smallholder farmers in the research region at no cost or with subsidies, as the types of hives have a favorable impact on the economic efficiency of honey producers. Second, as experience is the primary determinant of the economic efficiency of honey production, governments must expand their understanding of contemporary beekeeping. The economic efficiency of honey production is mostly determined by the education levels of the household. Therefore, it is necessary to provide practical based teaching to smallholder farmers on method and techniques of honey production's in the study area. Lastly, in the study area, the farmers were producing honey for selling to the market ad as source of income earning. However, the availability of infrastructure can limit the farmers' supply the honey output to the market. Due to this, they sell at low price at farm get. Hence, the rural road has to be constituted for smallholder farmers in the study area. The profitability of honey production in the study area and its impacts on the economic efficiency of honey production must be the main topics of future research.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Consent

The verbal consent was obtained during data collection from Horo Guduru Wollega zone agricultural office.

Disclosure

Megersa Adugna is the co-first author

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Authors have collected data from sample household and analyzed and wrote the article.

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