An Estimation of Technical Efficiency of Turmeric Production in Sri Lanka

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Abstract

While acknowledging that Sri Lanka's agriculture industry substantially contributes to the country's total agricultural output, experts have found that spices are not produced at total capacity. Turmeric, for example, is still not wholly exploiting the country's abundant resources among agricultural export items. Due to challenges affecting input-related issues, this sector continues to have several inadequacies in production. This study employed data envelopment Analysis (DEA) to investigate the levels of technical efficiency scores for a sample of 200 Turmeric farmers in the six districts namely, Kurunegala, Gampaha, Matale, Kandy, Kaluthara, and Ampara under the assumptions of both constant returns to scale and variable returns to scale. The data relating to inputs and output under turmeric production and farmer characteristics were identified through a structured questionnaire. The outcome indicated that the mean input-oriented data envelopment analysis technical efficiency scores estimated for constant return to scale and variable return to scale were 0.782 and 0.887, respectively. According to the results, the utilization variable returns to scale, and the optimal resources available with prevailing technology increased technical efficiency by 12%.

Keywords: Turmeric production, Returns to scale, data envelopment analysis, input-oriented technical efficiency, Tobit model

01. Introduction

According to the Department of Export Agriculture in Sri Lanka (2019), the country produces around 2000 metric tons of turmeric and imports the rest of the demand from India. Annual import ranges from 5500 to 6000 metric tons, costing around Rs. 1142 million. Since 1986, turmeric cultivation has been kept up with unsolved technological, natural, and behavioral issues. Low productivity, rising production costs, high price fluctuations, illogical fertilizer use, financial capacities, unanticipated adverse climate changes, and ignorance of local turmeric quality are among those issues. The term "technical efficiency" refers to the maximization of output from a given level of inputs using the available technology. The

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technical efficiency of the turmeric farming industry can be applied to determine the farmers' ability to raise current output from a given level of inputs. If farmers keep their technical efficiency low, they can boost their yield from existing inputs by reducing inefficiencies in their production. This will most likely be significant in the long run because it improves economic efficiency by lowering costs (Chavas and Aliber, 1993). Further, it would be remedial to the above issues faced by turmeric farmers. Accordingly, this research intends to determine the technical efficiency of turmeric production in Sri Lanka. Further, this study concludes with critical initiatives to enhance the technical efficiency of Sri Lanka's turmeric industry, which will likely provide perspectives to the turmeric plantation sector, which is currently facing the same difficulty of increasing its resources. As Sri Lanka runs into an inefficiency problem in utilizing its current turmeric resources, this research examines if turmeric farmers can increase their output without an additional input cost.

02. Research Problem

As a rapidly growing sub-sector in Sri Lankan agricultural economy, the turmeric sector needs to attend to maximizing efficiency in the utilization of its existing resources in order to get the maximum possible production. More precisely, the farmers who engage in this sector need to be technically efficient, although evidence suggests that it operates below the potential level due to the inefficient component in the production process involved in turmeric cultivation (Hosaman, 2017). Hence Sri Lanka has an inefficient dilemma in utilizing their existing resources in the turmeric sector. Therefore, this study addresses whether turmeric farmers are potentially capable of improving their production without incurring any additional input. This exploration will probably be an opportunity for them to improve their level of efficiency by conquering inefficiencies. Thus, this study researched the turmeric sector to estimate their technical efficiency level to identify their ability to obtain maximum production from a given set of inputs and available technology. Therefore, the outcomes of this study would probably provide insights to turmeric farmers in maximizing their output by optimizing their existing resources. Further, these study outcomes would provide implications to responsible authorities of the turmeric industry in directing the farmers to improve efficiency.

03. Review of the Literature

In Sri Lanka, very few empirical efforts have been made to measure the technical efficiency and have assessed the focal factors of this technical efficiency in turmeric production. Available literature suggests that farmers in developing countries fail to exploit the full potential of technology and make allocative errors (Taylor & Shonkwiler, 1986; Ali and Flinn, 1989; Kalirajan and Shand 1989; Bravo-Ureta and Evenson, 1994; Shanmugan and Palanisami, 1994; Sharma and Datta, 1997; Thomas and Sudaresan, 2000, IWMI, 2002; and IPRI, 2010). Joseph Philip et al (1980), in their National-level Seminar paper titled, "Variation of Yield and Quality of Turmeric by the Cultivators" stated that the optimum period of harvest of rhizome at Vallanikkara (Kerala) was 270 days after planting, for obtaining the highest yield of turmeric. Govind et.al, in their study titled, (1981) "Character Association and Selection Index in Turmeric" analyzed the various growth attributes of turmeric. They concluded that the height of the plant was an important measure of growth. The study also revealed that plant height was positively associated with rhizomes yield in turmeric. Amarasuriya, Edirisinghe, and Patalee (2010), mentioned that Plant Density affects the yield of turmeric production. Bandara, Lankapura & Idamekorala (2020), have done research to analyse major turmeric Growing Districts and emphasized that turmeric production was found to be a profitable venture in Kurunegala, Kandy, and Kegalle. The schools of studies in chemistry at Jiwali University (2012), emphasize that turmeric has a high level of herbal value, value for human deceases. Madushanka, Thilakarathne, Liyanage, and Navarathne have done an analysis of curcumin content in Sri Lankan and Indian turmeric. They emphasized that the turmeric types with a high curcumin content appear bright yellow while turmeric with a low curcumin content appears orange-yellow and Sri Lanka turmeric has a high value of curcumin than Indian turmeric. Keith (2020), Hamid Nasri, (2014), Labban (2014), Saeed and Bashir, (2019), Dipendhi (2018), and Muhammad Bilal emphasized the importance of turmeric for medicine. Moreover, Guil discusses (2019), that the use of turmeric as a feed supplement for birds and its influence on animal Health. Srikrishnah and Suthram (2018), emphasized that the growth and yield performance of turmeric plants were better under 50% shade level.

3.1. The Concept and Measurement of Technical Efficiency

Technical efficiency is an important element of productive efficiency and it is derived from the production function (Forsund, Lovell, & Schmidt, 1980). Technical efficiency can be conceptualized as the maximum achievable level of output for a given level of inputs, given the current level of alternative technologies available (Ellis, 1993). The concept of efficiency is linked with this frontier model and subsequently applied by many researchers in their work related to productive efficiency (Afriat, 1972; Aigner, Lovell, & Schmidt, 1977; Førsund, Lovell, & Schmidt, 1980; Kumbhakar & Lovell, 2004). According to Farrell (1957), Technical efficiency is defined as the ability to achieve a higher level of output given a similar level of inputs. Typically, there are two widely used approaches to analyze relative efficiency measures. These are the nonparametric or data envelopment analysis (DEA) and the parametric or stochastic frontier analysis (SFA). In order to examine the production function's parameters, SFA establishes a functional connection between inputs and outputs. The ability to test hypotheses is one discerning feature of the stochastic model specification of SFA, according to Coelli (1995). The drawback of the SFA method is that it demands specific assumptions about the distribution of the error component and the frontier's functional form. Using methods from linear programming, DEA creates a piecewise frontier of the data as opposed to SFA. DEA highlights any deviations from the production frontier to inefficiency because it is deterministic in nature and nonparametric in nature, so it does not require any assumptions about functional form or distribution type (Coelli, 1995). Nonparametric frontier approaches are thought to have a significant advantage over parametric measurements because of the efficient frontier's formless structure that the DEA method provides.

In this study, TE was calculated using DEA models, under the constant returns to scale (CRS) and variable returns to scale (VRS) assumptions. The CRS assumption mandates that any increase in input will result in a corresponding increase in output, according to Färe et al. (1985). This efficiency measurement is also referred to as an overall TE measure because it will take both controllable and non-controllable sources of inefficiency into account. Since scale inefficiencies and the assumption that output will not rise in line with a rise in inputs are taken into account, the projected production frontier of VRS, as opposed to CRS, more closely encircles the data points. This metric sometimes referred to as a pure TE measure, does not link inefficiencies to scale disparities (Färe et al., 1985). In contrast to the CRS assumption, which maintains that all farms are operating at their optimal scale, the VRS assumption argues that not all farms are scale-efficient. This implies that scale inefficiencies occur if efficiency under the two assumptions (CRS & VRS) differs.

04. Theoretical Framework

In Figures 1 and 2 below, the theoretical framework on efficiency for input orientation and output orientation developed by Farell (1957), Battesse (1992), and Coelli (1996) is visually depicted. We assess the ability to minimize inputs while maintaining a fixed output while using the input strategy, which takes waste prevention into account by generating as much output as input utilization permits. The unit isoquant of fully efficient companies, shown by SS' in Figure 2.1, provides the assessment of technical efficiency when a firm uses two inputs (X1 and X2) to produce a single output (q), under the assumption of continuous returns to scale. CE explains Cost Efficiency while AE explains Allocative Efficiency. The range QP, or the range by which all inputs might be if a certain company uses quantities of inputs, as indicated by the point P, to produce a unit of output, the distance QP, which is the amount by which all inputs might be proportionally reduced without a loss in output, could be used to define the technical inefficiency of that company. The ratio, which is most frequently used to gauge a firm's technical efficiency (TE),

TE = 0Q/ 0P,
CE = 0R/ 0P,
AE = 0R/ 0Q,
TE ‹ AE = (0Q/ 0P) ‹ (OR/0P) = CE

One less than this is equal to QP/0P. It permits a number between 0 and 1, which acts as a gauge of their technological know-how. A rating of one indicates that the company's technological efficiency is 100%. Point Q in the image above, for instance, is technically efficient because it is located on the effective isoquant.

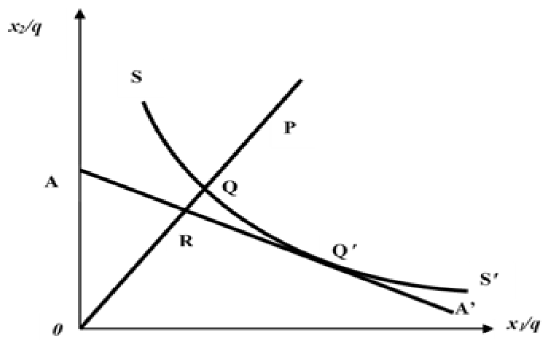

Figure 1. Input-Oriented Measure for Technical, Allocative, and Economic Efficiencies

Source: Farell (1957); Coelli et al. (1998)

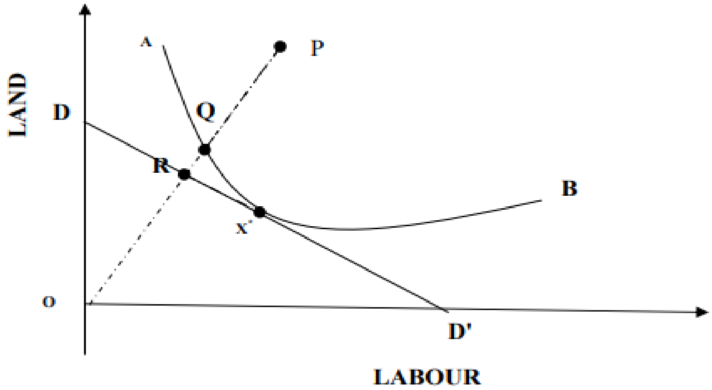

Figure 2: Economic Efficiency

Source: Farell (1957); Coelli et al. (1998)

Figure 2.1 is a diagrammatic exposition with a simple example of firms using two inputs land and labour to produce turmeric. Firms producing along AB are said to be technically efficient because they are operating on the "efficiency frontier" or the isoquant, although they represent different combinations of land and labour inputs, used in producing output Q. This is the least cost combination of inputs. In addition, DD' is an iso-cost line, which represents all combinations of inputs land and labour, such that input costs sum to the same total cost of production, given the firm's budget. However, any firm intending to maximize profits has to produce at Q', which is a point of tangency and represents the least cost combination of land and labour in the production of Q metric tons of turmeric. Therefore, at point Q' the producer is economically efficient. To illustrate the measurement of technical, allocative, and economic efficiency, we can suppose a bean-producing firm whose output is depicted by isoquant AB, with input (land and labour) combination levels as in Figure 2.1. At point (P) of the input combination, the production is not technically efficient because the farmer can instead produce at Q (or any point on AB) with fewer inputs. The degree of technical efficiency of such a firm is given as TE= OQ/OP.

For a fully efficient firm TE = 1, but for all inefficient firms, a degree of TE < 1 is achieved. The difference between the estimated TE and 1 (or TEi-1) depicts the proportion by which the firm should reduce the ratios of both inputs used to efficiently produce a metric ton of beans (Gelan & Muriithi, 2010). However, TE does not take into account the relative costs of inputs. In Figure 1, DD' represents the input price ratio or the iso-cost line, which gives the minimum expenditure a firm intending to maximize profit should adopt. The same firm using land and labour to produce beans at P would be allocative inefficient compared to that producing at R, and its level of allocative efficiency is given by OR/OQ. The overall (economic) efficiency is given as the product of the technical efficiency measure (OQ/OP) and the allocative efficiency measure (OR/OQ), which is OR/OP. This follows from the theoretical reduction in costs due to the shift in input combination from P to R. In this case, if a technically and allocative inefficient producer at P were to become efficient (both technically and allocatively) then she would produce at Q'.

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The output approach is used when evaluating the capacity to minimise waste by utilising as few inputs as output production permits, i.e., we assess the capacity to maximise outputs while maintaining constant inputs. Another definition of technical efficiency is the ability of producers to combine resources in the best way feasible to create products and services with a minimum amount of waste. There is no material input waste. There aren't any employees waiting aimlessly for replacement parts. With the given resource input, the most physical production is produced. In essence, manufacturing is accomplished with the least amount of lost opportunity. The distance AB in Figure 2.2 stands for technical inefficiency, or the extent by which outputs could be enhanced without necessitating more input. Consequently, an output-focused measure of the ratio is technical efficiency,

TE = 0A / 0B,
AE = 0B / 0C,
RE = 0A / 0C,
RE = TE ‹ A

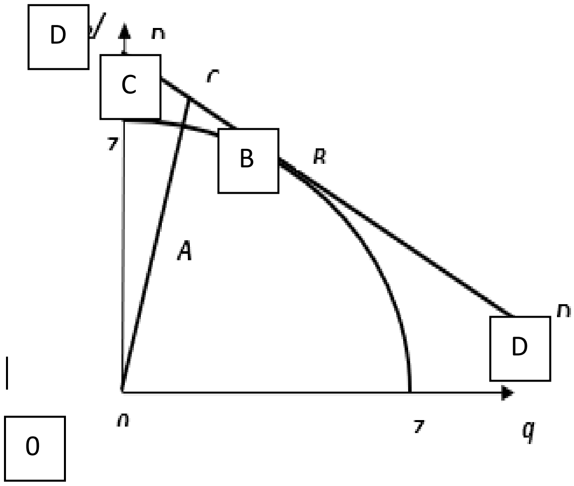

Figure 3: Output-Oriented Measure for Technical, Allocative, and Economic Efficiencies

Source: Farell (1957); Coelli et al. (1998)

05. Materials and Methods

5.1. Sample and Sampling Procedure

The turmeric Farmers that work in Sri Lanka to cultivate turmeric made up the study's population. The study sample was chosen from the population using a multistage random selection process. On the basis of data from the Department of Export Agriculture (2019) and Abeynayaka et. al., (2020) in Sri Lanka, the districts of Gampaha, Kandy, Kaluthara, Kurunegala, Ampara, and Matale were chosen for the sampling frame. Turmeric production is practiced by around 12,900 farmers in those districts. The sample size was calculated with a 7% margin of error. Because this is a quantitative research design, the questionnaire survey is the primary data-gathering instrument. Questionnaires were used by the researcher to obtain data from the individual turmeric farmers in the sample for one year (season). As a result, this research used primary data. A cross-sectional survey of turmeric farmers in the six districts yielded primary data. In each district 33 data were collected by the researcher from the farmers.

5.2. Data Collection

The study used primary data that were collected using a structured questionnaire that covered the demographic, socio-economic, and farm characteristics of the farmers. The questions asked about the respondents' age, the number of family members, educational level of household head, and farming experience. Data requested on the amount of turmeric output obtained in Kg and inputs including the size of land in acres, amount of seed in Kg, and labour hours were also asked in the questionnaire.

5.3. Sampling Technique

On the basis of data from the Department of Export Agriculture (2019) and Abeynayaka et. al., (2020) in Sri Lanka, the turmeric farmers are located in the districts of Gampaha, Kandy, Kaluthara, Kurunegala, Ampara, and Matale and they were considered as the target population of this study. Turmeric production is practiced by around 12,900 farmers in those districts and from this population, 200 turmeric farmers were selected using a combination of purposive, multi-stage, and random sampling techniques. In the first stage of data collection, six districts in Sri Lanka were selected due to the predominance of turmeric production in these areas, and in the second stage, 200 turmeric farmers were selected randomly from each district in proportion to the size of the population of turmeric farmers.

06. Data Analysis

This study used mainly two approaches: data envelopment analysis as a non – parametric in the first step, followed by the application of the Tobit regression model. The data envelopment analysis (DEA) was employed to estimate the technical efficiency of turmeric farmers using the data envelopment analysis program (DEAP) package. After estimating the technical efficiency scores using the DEA, to evaluate the impact of demographic, and socio-economic characteristics of farmers, and farm characteristics on technical efficiency, the Tobit model was used in the study.

DEA is a nonparametric approach that calculates the technical efficiency scores under the assumptions of constant returns to scale (CRS) and the variable returns to scale (VRS) on a sample of farms. The CRS model assumes that all farms operate at an optimal scale. However, the turmeric farmers in the study area were found to deal with many problems such as financial constraints, fluctuating inputs, unreliable labor supply, pests, and diseases that cause only part of the farms to operate at the optimal level. It is suggested that there is no reason to assume that CRS exists in the production of turmeric at the farm level. Thus, the use of the VRS was assumed as suitable to evaluate the technical efficiency of turmeric farmers by adding convexity constraints to the constant returns to scale assumption in the DEA model.

Farrell (1957) provided a linear programming method to determine the non-parametric boundary, and the efficiency index for a certain farm to i determined by comparing the input and output. Additionally, it is not necessary to assume that nearby technologies or ineffective distribution exist. Farrell (1957) defined efficiency as the difference between a farm's actual output and its potential output, which is referred to as the production frontier. As a result, the output of the average distance measurement from the frontier level represents the efficiency of agricultural production. Coelli (1996) created a multi-stage technique and computer software (DEAP) that, among other things (Alemdar and Oren, 2006), implements a reliable multi-stage model. Scale efficiency is measured as a ratio of technical efficiency scores achieved under the CRS and VRS assumptions. The DEA model, which is based on the Constant Returns to Scale (CRS), is described as follows by Coelli (1996).

$min\theta, \lambda\theta,$
Subject to - $yi + Y\lambda \geq 0,$
$\theta xi - X\lambda \geq 0,$
$\lambda \geq 0$ .... (1.0)
where θ is the scale of technical efficiency for each farm, $\lambda$is as $N \times 1$ vector of constants, $yi$and $xi$is the total output and farm inputs$i$, i= 1,2, ..., n. The value of $\theta \leq 1$ indicates the level of production reflects the production frontier and technically efficient farms. The equation (1.0) has used the assumption that all farms operate at an optimal scale. However, constraints such as finance and imperfect competition that occur in the field cause only part of the farm to operate at that level.

The VRS model is formed by inserting the constraints $N1'\lambda$= 1 in equation (1.1), where $N1$ is $N\times$ 1.

$min_{\theta, \lambda}\theta,$
subject to - $y_i + Y\lambda \geq 0,$
$\theta x_i - X\lambda \geq 0,$
$\lambda \geq 0$ .... (1.0)

where θ is the scale of technical efficiency for each farm, $\lambda$is as $N \times 1$ vector of constants, $y_i$and $x_i$is the total output and farm inputs$i$, i= 1,2, ..., n. The value of $\theta \leq 1$ indicates the level of production reflects the production frontier and technically efficient farms. The equation (1.0) has used the assumption that all farms operate at an optimal scale. However, constraints such as finance and imperfect competition that occur in the field cause only part of the farm to operate at that level.

The VRS model is formed by inserting the constraints $N1'\lambda$= 1 in equation (1.1), where $N1$ is $N\times$ 1.

$min_{\theta, \lambda}\theta$
subject to -$y_i + Y\lambda \geq 0$
$\theta x_i - X\lambda \geq 0$
$\lambda \geq 0$
$N1'\lambda = 1$ .... (1.1)

Where,
Y = output matrix for 'n' Turmeric farmers
X = input matrix for 'n' Turmeric farmers

θi = VRS technical efficiency score of the ith Turmeric farmers
λj = n × 1 constraint yi = output for ith Turmeric farmers in kilogram
xi = inputs vector of x1ij, x2ij, and x3ij inputs of the ith Turmeric farmers
$xi1$ = Size of the land in Acre
$xi2$ = Amount of seeds in Kg
$xi3$ = Labour hours

6.1. Tobit Regression Model

After estimating the technical efficiency scores of turmeric farmers, the Tobit regression model was used to examine the impact of demographic and farming characteristics on technical efficiency under constant returns to scale, variable returns to scale, and scale-efficient specifications.

This model used as a censored regression, was initially examined in the econometric literature and was developed by Tobin. Since the efficiency index produced by data envelopment analysis is restricted to values between 0 and 1, it can be used as a dependent variable in the Tobit model to examine the factors influencing the technical efficiency among farmers. Based on earlier research, a regression model was utilized to determine the influence of farmers' productivity using Ordinary Least Square (OLS). Some claim that the estimation of OLS is inconsistent and inefficient compared to Tobit regression and where the dependent variables have a censored range of 0 to 1, the Tobit model is more appropriate than the OLS model. For these types of cases, a number of scholars have also used the Tobit model in their research in the past thirty years.

Tobit's model can be written as follows:
$y^*_t = x'_t\beta_0 + \epsilon_t$, where, $t = 1,2,3, \ldots, n$ .... (1.2)
$y_t = y*_t$ if $y^*_t > c$; then, $y_t = c$, otherwise ....(1.3)

Where,
y_t is an efficiency score used as a dependent variable, $\epsilon_t x_t$ is N (0, σ^2) and (y_t, x_t) (t = 1, 2.... n) is a vector of independent variables related to demographic and farming characteristics, the value of c is known while y_t* is a latent variable. β is an unknown parameter vector associated with the farm-specific attributes, and ε is an independently distributed error term that is assumed to be normally distributed with zero mean and constant variance, σ^2.

Using the above general form, the Tobit model used in the study can be specified as:
$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$
Where,
Y_i = Technical efficiency scores measured under CRS, VRS, and SE specifications
β_0 = Constant
β_1 to β_4 Coefficients of each explanatory variable
X_1 = Family size
X_2 = Education in years
X_3 = Experience in years
X_4 = Possibility of other income coded as 1 for yes, 0 for no
X_5 = Credit accessibility coded as 1 for yes, 0 for no
X_6 = Registered as a member under the farmers' organization coded as 1 for yes, 0 for no
ε = Error term

Several factors have been found to explain the levels of technical efficiency among farmers in the study area and based on the literature, age, number of family members, education level, and years of experience in farming were considered as independent variables in the study. The inclusion of these variables was justified based on surveys and interviews that were done during the research survey to determine how these variables impact the technical efficiency of turmeric farmers in the study area.

07. Results and Discussion

7.1. Descriptive Statistics of the Variables Used in Technical Efficiency Analysis

The variables utilized in the technological efficiency analysis (DEA) are shown in Table 1 with their descriptive statistics. Inputs to the study included the turmeric output in kg, size of the land in acres, number of seeds in kg, labour hours, age in years, number of family members, education in years, and experience in years. The findings indicated that the average turmeric output is 4170.85 kg per farmer. Seeds made up the majority of inputs, followed by labor and then land. The average farm size for producing turmeric was also found to be 3.62 acres, suggesting that the majority of the farmers in the study areas are large-scale farmers. Large farm sizes increase agricultural productivity and boost the technical efficiency of the turmeric industry in the survey area. The results show a wide range in annual production, from 20 kilograms to 400,000 kilograms, with a standard deviation of 2819.74 kilograms. The land lot measured 3.62 acres on average, with the lowest and highest values being 1 acre and 563 acres.

Table 1: Descriptive statistics of the variables

Variables	Minimum	Maximum	Mean	Standard deviation
Turmeric Output in Kg (per Farmer)	20	400000	4170.85	28197.74
Size of the land in Acre	1	563	3.62	39.72
Number of seeds in Kg	5	337800	1867.03	23874.48
Labour hours	1	20	6.84	1.92
Age in years	25	72.00	51.3350	9.71
Family members	2	5	3.8485	.75
Education in years	10	20	14.6414	3.54
Experience in years	1	39	4.6000	5.87
Overall technical efficiency (CRS)	.010	1.00	0.373	0.243
Pure technical efficiency (VRS)	0.30	1.00	0.613	0.209
Scale efficiency (SE)	0.02	1.00	0.602	0.283

On average, the overall technical efficiency score of turmeric farmers in the study area was 0.37 indicating that the farmers within the study area could reduce their inputs by 63% and still produce the same level of turmeric output. Also, the farmers have 38.7% of pure technical inefficiency and 39.8% of scale inefficiency which represents that, by eliminating scale inefficiency, the farmers can increase their average technical efficiency level from 37.3% to 61.3% in the turmeric farming in the study. Scale efficiency indicates whether any efficiency can be obtained by improving the size of the operation. For turmeric farmers, scale efficiency is moderate with an average of 0.60 indicating that the majority of the farmers are operating their farming at **a** moderate size. An input–oriented data envelopment analysis was used for estimating overall technical efficiency (TE_{CRS}), pure technical efficiency (TE_{VRS}), and scale efficiency (SE) for the turmeric farmers measured in Table 1.

7.2. Technical Efficiency

Using the automated program DEA 2.1, the input-oriented DEA analysis produced results that are shown in Table 1. These results show that overall technical efficiency (TECRS), which spans from 1% to 100%, has an average of 37% and a standard deviation of 0.243. 200 farmers had an average pure technical efficiency (TEVRS) of 61%, with a range of 30% to 100% and a standard deviation of 0.208. The sample mean and standard deviation for the aforementioned samples are 60% and 0.283 respectively, and the SE index for them spans from 2% to 100%. Table 2 shows the frequency distribution of technical efficiency scores derived from DEA analysis, and it shows that under CRS, 76% of the farmers reached the highest efficiency range of less than 50, while under VRS and scale efficiency, 40% and 41% of the farmers accomplished the efficiency range of less than 50.

Table 2: Frequency distribution of technical efficiency scores derived from DEA

	TE_{CRS}		TE_{VRS}		SE	
Efficiency range	Frequency	Percent	Frequency	Percent	Frequency	Percent
Less than 50	153	76.5	80	40.0	81	40.5
51-60	18	9.0	36	18.0	17	8.5
61-70	7	3.5	30	15.0	19	9.5
71-80	4	2.0	13	6.5	22	11.0
81-90	7	3.5	8	4.0	17	8.5
91-100	11	5.5	33	16.5	44	22.0
Total	200	100.0	200	100.0	200	100.0

Note: TE_{CRS}: – Technical efficiency from constant returns to scale, TE_{VRS}: – Technical efficiency from variable returns to scale, SE: – Scale Efficient

Table 3: Summary of returns to scale

Characteristics	Number of farmers	Percentage of the farmers
Constant returns to scale	9	4.5%
Decreasing returns to scale	2	1%
Increasing returns to scale	189	94.5%

Returns to scale indicate the number of farmers experiencing constant, decreasing, or increasing returns to scale at their optimal size. If the farmers have increasing returns to scale, they will benefit by becoming larger, whereas decreasing returns indicate the opposite. On the other hand, if the farmers are at their optimal size, they would suffer losses in efficiency from changing their scale of operation. According to the results of returns to scale across turmeric farmers shown in Table 3, out of 200 farmers, 9 showed constant returns to scale, and 2 showed decreasing returns to scale. 189 showed increasing returns to scale indicating that farmers would improve their efficiency of resource use by increasing in size. In general, the cause of inefficiency may have been either inappropriate scale or misallocation of resources. Inappropriate scale suggests that the farmer is not taking advantage of economies of scale, whereas misallocation of resources refers to inefficient input combinations. In this study, pure technical efficiency relatively high proves that. The farmers are not taking the benefits from economies of scale. (Oren & Alemdar 2006).

To identify the impact of socio–economic characteristics on technical efficiency among turmeric farmers, the Tobit regression model was employed in the study. Estimated Tobit regression coefficients and marginal effects of the explanatory variables on technical efficiencies are shown in Table 4.

Table 4: Estimations of the Tobit model and its marginal effects

Variables	Overall technical efficiency = CRS		Pure technical efficiency = VRS	
	Coefficients	Marginal effects	Coefficients	Marginal effects
Family size	0.038^{**}(0.015)	0.020	0.097^{***} (0.016)	0.011
Education	0.009^{**}(0.003)	0.005	0.012^{***} (0.004)	0.001
Experience	0.006^{**}(0.003)	0.003	-0.001 (0.003)	-0.0002
Other income	0.085^{**}(0.036)	0.045	0.107^{***} (0.039)	0.012
Credit accessibility	0.050 (0.059)	0.027	0.043 (0.063)	0.004
Registered	0.023 (0.041)	0.012	0.044 (0.044)	0.005
Number of observations	198		198	
Uncensored	188		167	
Left – censored	1		1	
Right - censored	9		30	
F (6,192)	78.03		184.84	
Probability > F	0.000		0.000	
Pseudo R^2	0.866		0.777	
Log likelihood	-18.28		-50.21	

Note: *** and ** represents the significant levels at 1% and 5% respectively.

Standard errors of the estimates are shown in parentheses.

Tobit regression analysis was also used to find the factors that affect turmeric producers' technical efficacy in the study. The scale efficiency of the farmers, the score of technical efficiency of constant returns to scale, and variable returns to scale are used as the dependent variables in the Tobit model, while the variables that were independent include factors like family size, education, experience, credit accessibility, registered in DEA (Department of Export Agriculture) and other income. As a result, three different Tobit regressions have been estimated in the analysis for the CRS, VRS, and scale efficiency criteria. The use of the conventional least-square regression model is inappropriate since the scores are confined between zero and one. A Tobit regression model was used in the study since it is more appropriate in this situation. The relationship between family size and technical efficiency is positive, and statistically significant at the 5% level, and it indicates that turmeric farmers with larger families are more technically proficient than those with smaller families. This is likely a result of the fact that farmers with big household sizes frequently try to increase output in order to provide for their basic needs. Additionally, large household size has the labor resources needed to put management decisions for cattle farms into action. The probability of family size efficiency under CRS and VRS will be higher by 0.02% and 0.011%, respectively, according to marginal effects for family size.

08. Conclusion

This study used data envelopment analysis to determine the technical efficacy of turmeric farmers in all six districts utilizing the input orientation assumptions with variable returns to scale and constant returns to scale specifications. In the study, the Tobit regression model was used to analyze the determining elements that affect the technical efficiency under the three requirements mentioned above. The results of data envelopment analysis show that scale efficiency in the samples was evaluated at 60%, while technical efficiency for the CRS and VRS was calculated at 37% and 61%, respectively. According to estimated VRS efficiency, the turmeric farmers in the study might use 39% less current inputs while still producing the same amount of output. 9 of the 200 farmers in this study were found to be working at constant scale (CRS), while the remaining 1% and 94.5% were at decreasing and increasing returns to scale respectively. This suggests that the majority of farmers were working under less-than ideal-circumstances, and as a result, they could still produce more production before reaching the point of diminishing returns to scale. family size, education, experience, and other income are the main variables with a significant and positive influence on all three specifications scores of technical efficiencies in turmeric farming in the study, according to the results of Tobit regression, which was used in addition to the estimate of technical efficiency scores to examine the factors that determine the technical efficiency scores under various requirements.

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