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Determinants of Technical Efficiency of Rose Cut-Flower Industries in Oromia Region, Ethiopia

Mohammed Aman
School of Agricultural Economics and Agribusiness, Haramaya University
P.O.Box +251 138, Dire Dawa, Ethiopia
Email: rosemuhe@gmail.com or muhecristy@gmail.com

Jema Haji
School of Agricultural Economics and Agribusiness, Haramaya University
P.O.Box +251 233, Haramaya, Ethiopia
Email: jemmahaji@gmail.com or jema.haji@ekon.slu.se

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Abstract

The objective of this study is to measure and identify input use efficiency level of 28 rose cut flower industries in three districts of Oromia Regional state (Ethiopia) using a two stage approach. . In the first stage, a non-parametric (DEA) method was used to determine the relative technical, scale and overall technical efficiencies. In the second stage, a Tobit model was used to identify sources of efficiency differentials among industries. The results obtained indicated that the mean technical, scale and overall technical efficiency indices were estimated to be 92%, %61 and 58%, respectively for the cut flower industries. This Implies, major source of overall technical inefficiencies was scale of operation rather than pure technical inefficiency. Besides, the estimated measures of technical efficiency were positively related with Farming experience, formal schooling years of manager's and negatively related with age of farms. No conclusive result was obtained for the relation between size and efficiency.

Key words: Technical Efficiency, Scale Efficiency, DEA, Tobit, Rose cut flowers, farming experience, Oromia, Ethiopia.

1. Introduction

Diversification of agricultural production is seen as a priority for least developing countries to reduce dependence on primary commodities. The main reason is, despite high dependence on these commodities for their livelihood, declining trend of prices for primary agricultural commodities (Humphrey 2006). Accordingly, floriculture sector is chosen for enhancing farm incomes and reducing poverty in developing countries. In particular, African countries have a comparative advantage in rose flower varieties production. Fewer economies of scale and labour-intensive nature of production in cut flower industries are major sources comparative advantage for these countries (Labaste 2005).

Due to suitable climatic conditions and natural resources; high level of support by the government; favorable investment laws and incentives; proximity to the global market (mainly Europe) and availability of abundant and cheap labour, Ethiopia is the second largest producer of rose cut flowers in Africa following Kenya (Habte 2007). Moreover, the cut-flower industry in Ethiopia has emerged as one of the biggest sources of foreign exchange earning in recent years. This is mainly because of increased demand for cut-flowers, in the world market, by countries like Netherlands, Germany, Italy, United States, United

Kingdom and Switzerland (Belwal & Chala 2007).

Despite above opportunities, the high costs of technology, knowledge intensity of production, lack of access to capital, strict market regulations and standards; and demanding infrastructural requirements along with non existence of diversity in cut flower exports i.e. more than 80 % are a single rose variety, made the country not to benefit much (Melese 2007). To achieve simultaneous cost reduction and higher yield level of rose cut flowers, improving the resource use efficiency of these industries is relevant. And hence, this study is designed to estimate technical efficiency level and to identify its main determinants in the production of rose cut flowers in Awash Melkassa, Bishoftu and Ziway districts, respectively. These study areas are chosen due to relative similarity in terms of their geographic characteristics, market conditions, production practices and type of rose cut flowers grown.

In particular, this study tries to answer following questions; what is the existing level of efficiency of rose cut flower industries in the study areas? Is there any room for improvement in the level of efficiency for rose cut flower industries? What are the main causes for the existing level of efficiency? What are the main possible solutions to improve the existing level of efficiency in rose cut flowers production? By what level will input(s) be reduced to obtain the existing yield level of rose cut flower stems?

The rationales for this study are, identifying the technical efficiency level of the rose cut flower industries, will help business owners as to what extent they can reduce scarce resource use while maintaining current yield level of rose cut flower stems. Moreover, due to recent development of the sector in Ethiopia, checking for technical efficiency of these farms will also help policy makers in future policy design.

2. Materials and Methods

2.1. *Sources and Types of Data*

Primary data on the industry features, characteristics and production processes are collected through an interview with farm managers using a semi-structured questionnaire from the 28 rose cut flower industries. Whereas, the secondary cross sectional data on input and output for one growing season (45 days) were collected from each daily input use records in order to calculate the variables required for the empirical analysis. The data used in this study was drawn from a survey conducted from December 7, 2010-January, 2010/11, in the three districts.

2.2. *Methods of Data Analysis*

Given N decision making units (DMUs) producing S products (outputs) using M inputs, input and output vectors may be represented by x_i and y_i, respectively. For each DMU, all data may be written in terms of $M \times N$ as input matrix (X) and $S \times N$ as output matrix (Y). Under the assumption of CRS, the linear programming model for measuring the technical efficiency of rose cut flower farms can be given as follows according to Coelli *et al.* (1998)is:

$$Min_{\theta,\lambda}\ \theta$$
Subject to $-Y_i + Y\lambda \geq 0$
$$\theta X_i - X\lambda \geq 0$$
$$\lambda \geq 0$$

Where,

Y_i - $(S \times 1)$ Vector of rose cut flower stems by the i^{th} industry

X_i - $(M \times 1)$Vector of inputs of the i^{th} rose cut flower industry.

Y - Rose cut flower stems output matrix $(S \times N)$for (N) cut flower industries.

X - Rose cut flower production input matrix $(M \times N)$for N rose cut farms.

θ - The input oriented technical efficiency score having value $0 \leq \theta \leq 1$.

If $\theta = 1$, the industry will be technically efficient; otherwise inefficient. And

λ- $(N \times 1)$Vector of weights which defines the linear combination of peers of the i^{th} industry.

The specification of CRS is only suitable when all $DMUs$ work at optimum scale. Otherwise, measures of technical efficiency can be mistaken for scale efficiency. Therefore, the CRS model is reformulated by imposing a convexity constraint. Technical efficiency measure obtained with VRS model is also named as 'pure technical efficiency', as it is free of scale effects. Thus, technical efficiency (TE) with VRS in DEA model could be obtained from following linear programming:

$Min_{\theta,\lambda}\ \theta$
Subject to $-Y_i + Y\lambda \geq 0$
$N1'\lambda = 1$

And $\lambda \geq 0$

Where, $N1'\lambda = 1$ is a convexity constraint ($N1$ is an $N \times 1$ vector of ones) and other variables are as defined in the CRS model.

When there is a difference in efficiency score values between CRS and VRS models, scale inefficiency is confirmed, indicating that the return to scale is variable, i.e. it can be increasing or decreasing (Färe & Grosskopf 1994). Scale efficiency values for each analyzed $DMUs$ can be obtained by the ratio between the scores for technical efficiency with CRS and VRS. If the ratio value equals to 1, it indicates $DMUs$ are scale efficient and a value less than 1 imply scale inefficiency. Furthermore, DMU operating with Decreasing Returns to Scale (DRS) is operating under super-optimal condition while those operating with increasing Returns to scale (IRS) are assumed to operate under sub-optimal conditions.

After efficiency scores are obtained, to identify the determinants of efficiency, a Tobit model is used for the second-stage relationship between efficiency measures and suspected correlates of inefficiency (Binam *et al.* 2003; Iráizoz *et al.* 2003; Chavas *et al.* 2005; Barnes 2006). The reason for using Tobit model for DEA efficiency scores is the bounded nature of efficiency level between 0 and 1. In this case, estimation with OLS would lead to biased parameter estimates (Green 1991; Dhungana *et al*. 2004). Rather a two-limit Tobit regression is estimated using commonly used statistical software STATA version 10.

2.3. *Definition of Variables*

The dependent variable, in first stage, is given by total number of rose cut flower stems produced. While, the independent variables included in this stage are: land measured by total hectare of land under greenhouse, the total labour (total number of temporary and permanent), water (the total amount of water (m^3) used in the greenhouse rose cut flower farms), the rose plant seedlings (estimated by the total number of rose flower plant seedlings stems used by the farms.), nitrate, sulphate and acid fertilizers measured by (kg) used.

In the second stage, however, the dependent variable is the technical efficiency score level of the rose cut flower industries. Then this dependent variable is regressed over the following farm specific socio-economic variables. Average area per greenhouses; location of the farm in KM (distance from the Bole International airport); Ownership (measured by dummy values of 1 if the rose cut flower farm is domestically owned and 0 if owned by foreign investors.); Age of the farm (years since the establishment of the rose cut flower farm); Manager's education level (formal schooling years spent by the farm managers) and Manager's farming experience (total years of farming experience by the farm manager's in same or related farming).

The output and inputs data, from the twenty-eight rose cut flower industries, are used to estimate the technical efficiency levels in the production of rose cut flowers by using DEAP version 2.1 with an input orientation option i.e. since the industries are targeted at minimization of input use.

3. *Results and Discussion*

3.1. *Descriptive statistics*

The mean land size holding, under greenhouses, in the study areas was 19.17 hectares, with minimum and maximum sizes of 4.98 and 42 hectares, respectively. While, the mean employment level was 536 workers. The mean amount of nitrate, sulphate and acid fertilizers used in greenhouses were 12.82 kg, 26.46 kg and 1.98 kg, respectively. Furthermore, the mean, water, rose flower plant seedlings and cut flower yield levels were 47,300 m^3, 1,066,500 and 9,671,800 stems, respectively.

3.2. *Efficiency (DEA) Results*

In this section, district as well as industry level technical efficiency results are discussed. For the sake of comparison, technical efficiency indices are estimated both under CRS and VRS along with scale efficiency level and type of returns to scale.

The district level technical efficiency results indicate that, industries at Awash Melkassa, Bishoftu and Ziway districts could reduce their input use by 24%, 64% and 22% without any loss of rose cut flower stems. While, the mean technical efficiencies, using VRS, were 100, 90 and 94 percent for Awash Melkassa, Bishoftu and Ziway districts, respectively (Table 1).

Table 1. Descriptive statistics of the technical efficiency scores of districts

Case	Districts	N	Mean	S.dev	Min	Max	Range
	Awash Melkassa	1	0.76	-	0.76	0.76	0.00
CRS	Bishoftu	13	0.36	0.22	0.14	1.00	0.86
	Ziway	14	0.78	0.34	0.15	1.00	0.85
	Total	28	0.58	0.35	0.14	1.00	0.86
	Awash Melkassa	1	1.00	-	1.00	1.00	0.00
VRS	Bishoftu	13	0.90	0.11	0.71	1.00	0.29
	Ziway	14	0.94	0.10	0.64	1.00	0.36
	Total	28	0.92	0.11	0.64	1.00	0.36

Source: Author survey, 2011.

Furthermore, results obtained indicate statistically significant difference in mean technical efficiency level for rose cut flower industries in case of CRS i.e. farms in Ziway district were performing well followed by farms in Awash Melkasa and Bishoftu districts. However, the difference was not statistically significant in case of VRS. This may be due to similar technologies of production used by rose cut flower industries. Frequency distribution of the technical efficiency scores in both CRS and VRS are given in Table 2. Accordingly 8 industries under CRS and 16 under VRS are technically efficient and the remaining technically inefficient.

Table 2. Frequency distribution of technical efficiency scores (VRS, CRS and SE)

Frequency of Technical Efficiency						
TE scores	CRS	Percent	VRS	Percent	SE	Percent
1.00	8	28.57	16	57.14	8	28.57
0.91- 0.99	2	7.14	2	7.14	3	10.71
0.81- 0.90	1	3.57	5	17.86	-	
0.71- 0.80	1	3.57	4	14.28	1	3.57
0.61- 0.70	-		1	3.57	1	3.57
0.51- 0.60	-		-		-	
0.41- 0.50	3	10.71	-		2	7.14
0.31- 0.40	5	17.86			6	21.43
0.21- 0.30	4	14.28			5	17.86
0.11- 0.20	4	14.28			2	7.14
Mean	**0.58**		**0.92**		**0.61**	
Minimum	0.14		0.64		0.19	
Maximum	1.00		1.00		1.00	
S.dev	0.35		0.11		0.33	

Source: Author survey, 2011.

3.3. *Returns to Scale of Industries*

The majority,19 (67.85%), of scale inefficient rose cut flower industries were operating under IRS with only one farm operating under CRS. Those operating under IRS are small industries that need to increase their size of operation. While, those operating under DRS are large industries operating above their optimal scale and thus could be better-off by reducing their size of operation. Accordingly, most of the scale inefficient industries, in the three districts, need to expand their size of holding to efficiently utilize their resources (Table 3).

Table 3. Efficiency and returns to scale distribution of rose cut flower industries

	Technical Efficiency			Returns to Scale		
	CRS	CRS	SE	IRS	CRS	DRS
Industries						
Efficient	8	16	8			
Inefficient	20	12	20			
Total	28	28	28	**19**	**8**	**1**
Mean	**0.58**	**0.92**	**0.61**			

Source: Own (Authors) calculation

The mean SE was 0.61 This result imply that , the average size of the greenhouse rose cut flower industries in the study areas is far from the optimal scale and an additional 39 % productivity gain could be feasible, provided they adjusted their farm's operation to an optimal scale.

The causes of inefficiency for the industries could be either inappropriate scale or misallocation of resources. Inappropriate scale suggests that industries are not taking advantage of economies of scale in rose cut flower production process. While, misallocation of resource refers to inefficient input combination. As shown in Table 3, the mean SE and TE (VRS) score were 0.61 and 0.92, respectively. This relatively low scale efficiency mean value indicates the main cause of technical inefficiency, for the rose cut flowers industries, is inappropriate scale (scale inefficiency) rather than misallocation of resources (pure technical inefficiency).

In this study, input slacks are also estimated. The input slacks, using the VRS technical efficiency measure (pure technical efficiency), indicate excess use of that input(s) relative to other peer farms. The mean slack values for land, labour, water, nitrate, sulphate and acid fertilizers and rose plant seedling inputs are 0.76 hectares, 478 workers,1,810 m3,1.3 kg,1.76 kg,0.22 kg and 130041 stems, respectively. Among fertilizers, smallest mean input slack value is obtained for acids followed by nitrates. The reason is that, acid fertilizers are used to clean the drip pipes and less frequently applied than the two fertilizers. The rose cut flower industries can reduce costs, incurred on inputs, by the amount of slacks without reducing production level of rose cut flower stems.

3.4. *Determinants of Technical Efficiency*

In order to examine the effect of relevant technological, farm specific and socio-economic factors on technical efficiency of rose cut flower farms, the input oriented VRS technical efficiency scores are regressed on the selected explanatory and farm specific variables using a two-limit Tobit model since efficiency scores are bounded between 0 and 1 (Table 4).

Table 4. Determinants of technical efficiency in rose cut flowers production

	The log likelihood estimates		The Robust standard estimates	
Variables	Parameters	Efficiency effect	Parameters	Efficiency effect
Constant(x_0)	*b0*	-0.976 (0.667)	*b0*	-0.976 (0.258)
X_1	*b1*	-0.020 (0.023)	*b1*	-0.020 (0.016)
X_8	*b8*	-0.004 (0.012)	*b8*	-0.004 (0.009)
X_9	*b9*	0.259 (0.101)	*b9*	0.259 (0.093)

x_{10}	*b10*	-0.009* (0.035)	*b10*	-0.009** (0.022)
x_{11}	*b11*	0.104** (0.039)	*b11*	0.103*** (0.028)
x_{12}	*b12*	0.048** (0.023)	*b12*	0.048*** (0.014)
Log likelihood		0.937	Log Pseudo likelihood	0.937
Sigma	δ	0.133	δ	0.133

*** Significant at 1%; ** significant at 5%; * significant at 10%. Standard errors were shown in parenthesis, (x_1= Average land area, x_8 =location, x_9 = ownership, x_{10} = age of industry, x_{11}= managers education and x_{12}= managers experience).

The result obtained for age of the industry shows a negative and significant effect on technical efficiency of rose cut flower production implying older rose cut flower farms are less technically efficient than new ones. While, the formal education schooling years and experience in same or related business of farm manager's has positive and significant effect on technical efficiency level of the farms.

Furthermore, the marginal effects for the determinants of technical efficiency were also estimated. And hence, for a unit percentage increase in years rose cut flower farms, technical efficiency decreases by 1 %. While, a one percent additional formal schooling years of the farm mangers will improve technical efficiency of the industry by 10.3 %. Finally, a one percent additional farming experience of the farm manager will improve technical efficiency by 4.8 % (Table 5).

Table 5. Marginal effects of efficiency variables after Tobit regression

	The log likelihood estimates		The Robust standard estimates	
Variables	Parameters	dy/dx	Parameters	dy/dx
x_1	*b1*	-0.020 (0.023)	*b1*	-0.020 (0.016)
x_8	*b8*	-0.004 (0.012)	*b8*	-0.004 (0.009)
x_9	*b9*	0.259 (0.101)	*b9*	0.259 (0.093)
x_{10}	*b10*	-0.01* (0.035)	*b10*	-0.01* (0.022)
x_{11}	*b11*	0.103*** (0.039)	*b11*	0.103*** (0.028)
x_{12}	*b12*	0.048** (0.023)	*b12*	0.048*** (0.014)

Source: authors own calculation

4. Conclusion

Results obtained indicated that there is a room to improve technical efficiency level of rose cut flower industries in the study areas. For instance, the mean scale efficiency value of 0.61 implying, on average, rose cut flower industries in the three study districts are not operating at their optimal farm size. Among the factors that are assumed to affect technical efficiency level, experience in same or related farming activities as well as more years of formal schooling by the farm manager increased technical efficiency level Whereas, age of the farm, along with rose cut flowers grown inside, decreased the technical efficiency level. As far as marginal gain in technical efficiency is concerned, formal years of schooling dominates that of farm manager farming experience in same or related farming activities.

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List of Tables

Appendices

Appendix Table A 1.Name and location of DMUs (rose cut flower farms)

DMUs	Name of the rose cut flower farm	District (location)
1	AQ Roses Plc	Ziway
2	Exp. Incorporated Chibo Flowers	Ziway
3	Sher flowers 8	Ziway
4	Braam Flowers PLC	Ziway
5	Ziway Roses PLC	Ziway
6	Sher Ethiopia PLC	Ziway
7	Rainbow Colors PLC	Bishoftu
8	Yassin Legesse J. Flower Farm	Bishoftu
9	Dugda Floriculture Dev't PLC	Bishoftu
10	Joytech PLC	Bishoftu
11	Bukito Agro Industry	Bishoftu
12	Friendship Flowers	Bishoftu
13	ZK Flower	Bishoftu
14	Eyasu Sirak Workineh Flowers PLC	Bishoftu
15	Olij Flowers PLC	Bishoftu
16	Minaye Flowers PLC	Bishoftu
17	Roshanara Rose PLC	Bishoftu
18	Super Arsity Flower PLC	Awash Melkasa
19	Sher flowers 1	Ziway
20	Sher flowers 2	Ziway
21	Sher flowers 3	Ziway
22	Sher flowers 4	Ziway
23	Experience Flowers PLC	Ziway
24	Evergreen Roses PLC	Bishoftu
25	Zubka General Business Flower Farm Plc	Bishoftu
26	Sher flowers 5	Ziway
27	Sher flowers 6	Ziway
28	Sher flowers 7	Ziway