DETERMINANTS OF COST EFFICIENCY OF SMALLHOLDER FARMERS: THE CASE OF RAISIN PRODUCERS FROM SOUTH AFRICA

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Abstract

The aim of this paper was to contribute to the limited body of knowledge on the factors that affect the cost efficiency of smallholder farmers from South Africa to help smallholder farmers to maximise their return from farming activities while operating in an environment characterised by a severe cash flow constraint. The cost efficiency levels of a group of smallholder raisin producers were found to be low, while regression results showed that only two of the characteristics that were hypothesised to influence cost efficiency were significant. The existing knowledge thus is insufficient to formulate specific actions for intervention to help the smallholder raisin producers to improve their ability to select least cost combinations of production inputs. Further research is necessary to better understand the dynamics of the process through which smallholder farmers decide on the combinations of inputs to use to help them benefiting from improved cost efficiency.

Key words: Cost efficiency; smallholder farmers; raisin producers; DEA.

1. Introduction

The Irrigated agriculture is believed to have a major role to play towards alleviating rural poverty in South Africa (National Planning Commission (NPC), 2012; Republic of South Africa (RSA), 2009; Water Research Commission (WRC), 2008). The performance of smallholder irrigation schemes in South Africa, however, remains to be poor (Van Averbeke, Denison, and Mnkeni, 2011). The poor performance may be attributed to the number of stumbling blocks that are well documented in the literature to constrain the participation of smallholder farmers in commercial agri-food chains (Jordaan, Grové, and Backeberg, 2014). Problem tree analyses for smallholder farmers in South Africa showed that the farmers perceive limited cash flow to be central to the problems they face to participate in commercial agri-food chains (Jordaan and Grové, 2012). The farmers argue that the cash flow constraint prevents them from ensuring the timely application of the recommended amounts of production inputs to ensure optimal production levels, and hence hampers their ability to guarantee a consistent supply of good quality products that is expected in commercial agri-food chains. Given the severity of the cash flow constraint, smallholder farmers are expected to place high priority on the selection of input combinations that would allow them to minimise their cost of production.

Smallholder farmers, however, perform very badly in terms of selecting least cost combinations of production inputs (Van der Merwe, 2012; Jirgi, 2013; Jordaan, Grové, and Matthews, 2013). The question thus is what are the determinants of cost efficiency which can be exploited as leverage points for intervention to improve the ability of smallholder farmers to select those combinations of production inputs that will allow them to produce their crops at minimum cost? Although cost efficiency is concerned with the selection of input combinations that will allow farmers to produce their crops at minimum costs (Coelli, Rahman and Thirtle, 2002) the topic of cost efficiency has not received the expected amount of attention from researchers (van der Merwe, 2012). Badunenko, Fritsch and Stephan (2006) found this phenomenon surprising since economists were traditionally concerned with the

selection of the least cost combinations of production inputs to produce crops. In South Africa information on the allocative efficiency of smallholder farmers is even scarcer as is evident from Van der Merwe (2012) who found only two studies (Speelman et al., 2008; Piesse, Von Bach, Thirtle and van Zyl, 1996) that explored allocative efficiency levels in smallholder agriculture in South Africa. Moreover, while Speelman et al. (2008) and Piesse, Von Bach, Thirtle and van Zyl (1996) have explored the allocative efficiency levels of the farmers, neither of the two studies explored the determinants of allocative efficiency of smallholder farmers from South Africa. Thus, at this stage, there is insufficient knowledge available to make workable and specific recommendations for intervention that will help the farmers to select the combinations of production inputs to produce their crops at least costs, and hence to benefit from the substantial financial gains as documented by Jordaan, Grové, and Matthews (2013).

The objective of this paper is to contribute to the limited body of knowledge on cost efficiency of smallholder farmers by examining the levels of cost efficiency of a group of smallholder raisin producers from Eksteenskuil, and exploring the farm and farmer characteristics that are associated with higher cost efficiency levels. By exploring the characteristics associated with higher cost efficiency levels, the results from this study are expected to contribute towards knowledge that may improve the ability of smallholder farmers to produce their crops at minimum costs, and hence to improve their financial performance even under their current cash flow constraints measured.

2. Data and methods

Data

The data was collected by means of a questionnaire survey during June 2011. All 60 members of Eksteenskuil Agricultural Cooperative (EAC) were invited to participate in the study. While 53 raisin producers completed questionnaires, 40 questionnaires were completed to a satisfactory level to justify inclusion in the analysis of the cost efficiency of the farmers. The data that was gathered include farm level production data, and also information on the characteristics of the farmers and their farms. More specifically, the production data include the quantities and prices of production inputs that were used to produce the raisins during the 2010/11 season, and the volumes of Thompson's Seedless raisins produced during the 2010/11 season. The production inputs that were used to estimate the cost efficiency scores include nitrogen, phosphorus, and potassium as nutrients for the grapevines, and labour. The characteristics of the farmers that are considered as potential determinants of cost efficiency include the age, levels of formal education, and experience of the farmers; the area of grapes harvested; the degree of specialisation in raisin production; and off-farm income that can supplement cash flow; the attendance of farmers' days and a course in financial record keeping; and the degree to which the skills that were obtained through the record keeping course was applied in decision-making activities during the 2010/11 production season.

Quantifying cost efficiency

Cost efficiency scores are calculated in two steps. In the first step the minimum cost to produce the current output level is calculated. The cost efficiency score is calculated in the second step by calculating the ratio of the minimum cost to the incurred costs. The minimum cost is calculated though the following linear programming model (Rosenthal, 2011):

$$cx^* = \min cx$$
$$Subject\ to:$$
$$x_{ijo} \geq \sum_{j=1}^{n} x_{ij}\lambda_j; \qquad (i = 1,\ldots\ldots,I)$$
$$y_{pjo} \leq \sum_{j=1}^{n} y_{pj}\lambda_j; \qquad (p = 1,\ldots\ldots,P)$$
$$\sum_{j=1}^{n} \lambda_j \leq 1 \qquad (j = 1\ldots\ldots,J)$$
$$\lambda_j > 0;$$

Where c is the price of the inputs used, cx^* is the minimum possible cost to produce the current output level and cx is the incurred cost. x_{ij} define the amount of input, i, used by decision-making unit (DMU) j. Y_{pj} is the amount of product p produced by DMU j and j_0 refers to the reference DMU for which the efficiency is calculated. λ_j indicates the non-negative weights that are optimised for each DMU.

In the second step the minimum possible cost that was calculated in the first step is divided by current costs to get the cost efficiency score. Cost efficiency thus is calculated as follows (Coelli, Rahman, and Thirtle, 2002):

$$\theta = \frac{cx^*}{Cx}$$

where θ is the cost efficiency score, cx^* is the minimum possible cost to produce the current output level and cx is the incurred cost.

A DMU that has incurred the minimum possible cost thus scores a cost efficiency score of one. DMUs who have incurred costs higher than the minimum costs score cost efficiency scores between zero and one.

Determinants of cost efficiency

McDonald (2009) argues that the linear unit interval model is a suitable data generating process (DGP) for efficiency scores. When transforming the estimated efficiency scores to the logarithm, the coefficients that are estimated with Ordinary Least Squares (OLS) regression are consistent and asymptotically normal under general conditions. The linear unit interval model is presented as follows:

$$y_i = x_i\beta + u_i \qquad (1)$$

where the are independently distributed with zero means, with the limit point possessing positive probability. Following the recommendation of McDonald (2009), the dependent variable, is the logarithm of the estimated cost efficiency scores that were estimated above. Given the relatively small sample of 40 respondents, bootstrap estimates of the coefficients are calculated to provide more accurate inferences (Mooney and Duval, 1993).

The factors that were hypothesised to influence the levels of cost efficiency of the raisin producers from Eksteenskuil ( ) are summarised in Table 1. i x

Table 1: Factors hypothesised to influence the level of cost efficiency of raisin producers from Eksteenskuil

Variable	Measurement scale	Expected sign
Personal characteristics		
Age	Number of years	+
Experience	Number of years	+
Education	Number of years successfully completed	+
Financial characteristics		
Access to off-farm income	Binary variable (Yes = 1, No = 0)	+
Farm characteristics		
Farm size	Size of land harvested (ha)	+
Specialised raisin production	Specialisation index (0 - 100%)	+
Human capital development		
Farmers' days attendance	Number of farmers' days attended (0-6)	+
Record keeping course attendance	Binary choice (Yes = 1, No = 0)	+
Record keeping course application	Likert scale from 0 - 5 (0 if not at all, 5 if completely)	+

Table 1 shows that the factors that were hypothesised to influence the cost efficiency of the farmers can be grouped into four groups. In general, it is hypothesised that the cost efficiency of the raisin producers is influenced by the personal characteristics of the farmers (age, experience and education), some of the financial and farm characteristics of their farming enterprises (access to off-farm income, farm size, and specialisation in raisin production), and farmers' participation in human capital development activities (attendance of farmers' days and record keeping course, and application of record keeping course). All of the actions and characteristics were hypothesised to have a positive impact on cost efficiency levels of the farmers from Eksteenskuil.

3. Results

Cost efficiency of smallholder raisin producers from Eksteenskuil

The estimated cost efficiency scores of the raisin producers from Eksteenskuil are presented as a cumulative probability distribution (CDF) in Figure 1.

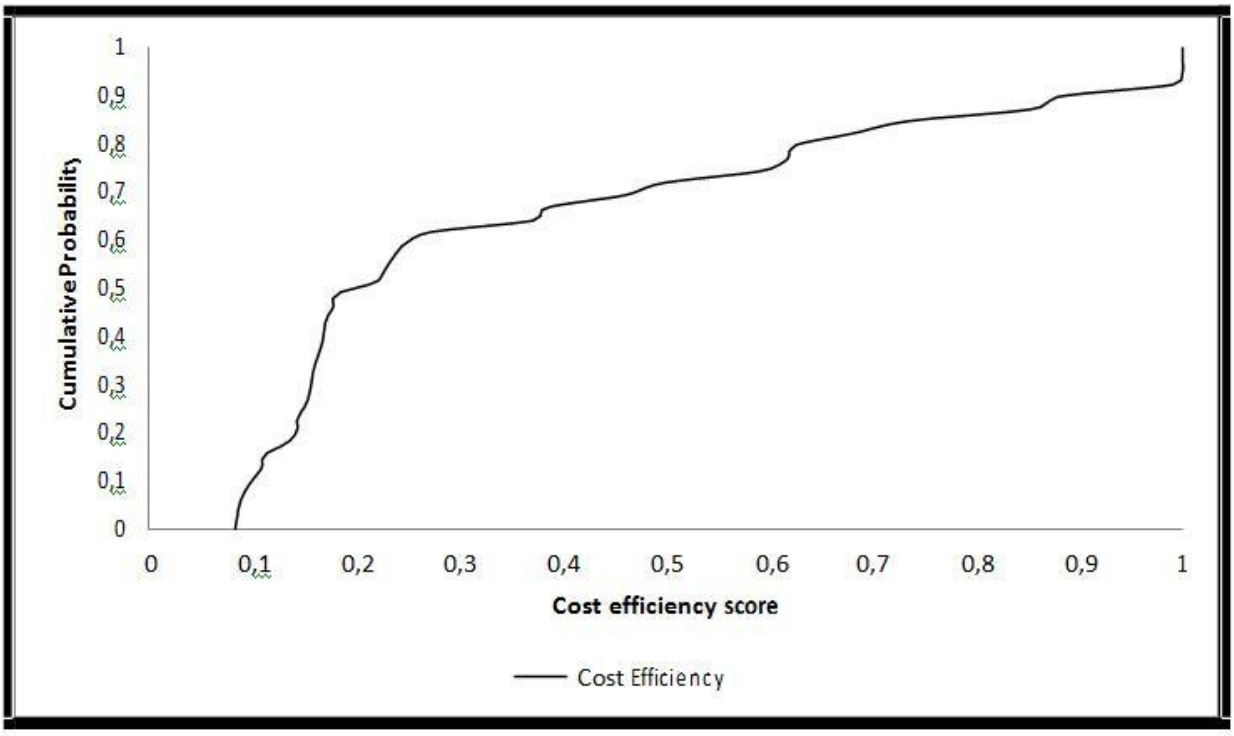

Figure 1: Cumulative probability distribution of cost efficiency scores of raisin producers from Eksteenskuil

Figure 1 shows that the cost efficiency levels of the raisin producers range from 0.084 to a maximum of one. There are three respondents who obtained cost efficiency scores of one. Three of the respondents thus have produced their output at minimum costs. The remaining 37 respondents are considered to be cost inefficient and thus could have produced their output at lower costs by selecting the cost minimising combination of production inputs. The cost efficiency score of 0.084 of the farmer who performed the worst in terms of cost efficiency implies that the farmer could have produced his/her raisins at only 8.4% of his current costs.

The slope of the CDF in Figure 1 suggests that there is a steep decline in the cost efficiency scores of the respondents for those respondents who were found to be cost inefficient. Only 30% of the respondents achieved cost efficiency scores between 0.3 and one. About 62% of the respondents achieved cost efficiency scores of less than 0.3. By implication, more than 60% of the respondents could have produced their current raisin yields at 30% or less of the cost they have actually incurred. The slope of the CDF changes drastically for the range of cost efficiency scores between 0.08 and 0.3. The steeper slope suggests that the decrease in cost efficiency scores is much smaller from one respondent to the next compared to the drop in the range of efficiency scores between one and 0.3. Thus, there proves to be major scope to improve the financial performance of the raisin producers from Eksteenskuil by supporting them to use their production inputs in a cost efficient manner.

When examining the distribution of the cost efficiency scores in more detail, the average cost efficiency score of the top third group of respondents is about 0.76. Thus, even the top third group of farmers (in terms of cost efficiency scores) could, on average, have reduced their costs substantially by selecting the correct combination of inputs to minimise costs. Compared to the relatively high average cost efficiency score of the top third group of farmers, the groups of farmers forming the middle and lower third groups achieved average scores of 0.23 and 0.12 respectively. The middle third group of farmers thus could have produced their outputs at an average of 23%, and the bottom third at an average of 12% of their current costs. Given the fact that limited cash flow is often listed as a major stumbling

block that contributes to the exclusion of smallholder farmers from participating in commercial agri-food chains, the poor performance of the farmers in terms of cost efficiency is a major cause for concern. By reducing production costs through selecting the optimal combination of inputs, more cash flow can be released to allow the farmers to apply the necessary production inputs closer to the recommended levels. Increasing the ability of the farmers to apply the recommended levels of production inputs may also have a positive influence on the technical efficiency of the farmers and hence further increase the benefit from improving the cost efficiency levels of the raisin producers from Eksteenskuil. Thus, clearly there is major scope to support the raisin producers from Eksteenskuil to improve their financial performance by selecting the cost minimising combinations of production inputs to produce their raisins. In the next section the focus shifts to the analysis of the determinants of cost efficiency to identify the characteristics of raisin producers that are associated with higher levels of cost efficiency.

Determinants of cost efficiency of smallholder raisin producers from Eksteenskuil

The results from the regression analysis to identify the socio-economic characteristics of the raisin producers from Eksteenskuil that influence their cost efficiency levels are shown in Table 2. Following the recommendation of McDonald (2009), the dependent variable is the log of the estimated cost efficiency scores. It is noted that, since the aim is not to predict the cost efficiency of the farmers but rather to identify characteristics that may influence cost efficiency levels, a probability of 15% is still considered significant.

Table 2: Ordinary Least Squares (OLS) regression results of factors affecting cost efficiency of smallholder raisin producers from Eksteenskuil1

Farm and farmer characteristics	Coefficient	Bias	Standard error	Sig. (2-tailed)
Intercept	-1.686	0.107	1.300	0.201
Personal characteristics				
Age	-0.020	-0.005	0.018	0.204
Experience	0.029*	0.003	0.021	0.110
Education	0.012	-0.004	0.085	0.874
Financial characteristics				
Off-farm income	-0.180	0.070	0.368	0.618
Farm characteristics				
Farm size	-0.031**	-0.001	0.028	0.056
Specialised raisin production	0.875	0.052	0.799	0.276
Human capital development				
Farmers' days attendance	0.077	0.016	0.086	0.351
Record keeping course attendance	-0.548	-0.155	0.876	0.456
Record keeping course application	0.144	0.039	0.237	0.456
F-statistic 1.481			1.481	

Prob (F-statistic) 0.200		0.200
Adjusted R-squared 0.100	0.100	

Note:

[1]: Results are based on 10 000 bootstrap samples

***, **, and * represent statistical significance at 5%, 10% and 15% respectively

The results in Table 2 show that the model is not a good fit to predict the variation in the cost efficiency levels of the farmers from Eksteenskuil. The probability of the F-statistic is greater than 10%, while the adjusted R-squared value (0.100) suggest that the model explains only 10% of the variation in the cost efficiency levels of the farmers from Eksteenskuil. Thus, there are other important factors that influence the cost efficiency of the farmers that are not included in the model. The variance inflation factors for all of the variables are less than four with only two variables ("Attend record keeping course" and "Apply skills from record keeping course") having variance inflation factors greater than two. Thus, there is no multicollinearity problem in the estimated regression model.

Of all of the variables that were initially hypothesised to influence the cost efficiency levels of the farmers only the levels of experience of the farmers and the size of their land under raisins were found to be significant at a 15% level of significance. The positive sign of the coefficient of farming experience (p <0.15) suggests that the higher the level of experience of the farmer, the higher is his cost efficiency level. The positive relationship is in accordance with the initial hypothesis. On the other hand, the negative sign of the coefficient of farm size (p <0.10) implies that larger farm sizes are associated with lower levels of cost efficiency. The negative influence of farm size on the cost efficiency levels of the farmers from Eksteenskuil is opposite from initial expectations. However, the negative relationship corroborates the findings by Okoye et al. (2007). Given the relatively low levels of human capital exhibited by the farmers from Eksteenskuil, the smaller scale of operations may improve the ability of the decision-maker to make better decisions with regard to the allocation of their production inputs. Thus, the negative relationship may actually be as a result of the characteristics of being small scale farmers with little experience of operating on larger pieces of land.

None of the other variables are statistically significant in explaining the variation in the cost efficiency levels of the farmers from Eksteenskuil. The results may be an indication that the low levels of cost efficiency documented above are not necessarily the result of poor selection of input combinations. The farmers are resource poor with limited means to ensure timely and sufficient application of important production inputs. The farmers' main concern thus is being able to apply the necessary inputs at all rather than selecting combinations of inputs that will minimise their cost of production.

4. Conclusions and recommendations

The results from the cost efficiency analysis show that the raisin producers from Eksteenskuil perform very badly in terms of selecting the cost minimising combination of production inputs to produce their raisins. The vast majority of farmers could have produced their raisins at a fraction of their current costs. The fact that only two of the variables that are normally found to influence allocative efficiency are significant in the case of Eksteenskuil may be an indication that the poor performance of the raisin producers in terms of cost efficiency is more associated with being small scale start-up farmers than with problems with their decision-making. Except for labour, the production inputs that were considered in the analysis of the cost efficiency of the farmers are nutrients for the grape vines that are applied as fertiliser or manure. The only way in which the farmers can decide to substitute one type of nutrient for another is by changing the fertiliser mixture or the type of manure (i.e. sheep or cattle) that is applied to the grapevines. Farmers who apply manure are very much restricted to the type of manure that is available to them. Most of the farmers who apply manure have some livestock for household consumption. Depending on the types of animals that are kept, the type of manure that is applied is relatively fixed. The

type of fertiliser mixtures to apply, on the other hand, normally is recommended by input suppliers based on the nutrient requirements of grapevines. The problem is that very few of the raisin producers from Eksteenskuil actually test the nutrient contents in their soil. The farmers thus have no idea of the true nutrient requirements for their soils. One way to ensure that the correct quantities and mixtures of fertiliser and the correct quantities of the specific type of manure are recommended is to support the farmers to get their soils tested. Knowing the true nutrient requirements to produce optimal volumes of grapes will enable the farmers to select a fertiliser mixture that may decrease their costs without having a substantial negative impact on the yields obtained. As such the farmers may be able to improve their cost efficiency levels and hence their financial performance. Ultimately, the conclusion is that very little is known about the factors that contribute to higher levels of cost efficiency of smallholder farmers in South Africa. More information is required to better understand the decision making process through which smallholder farmers decides on the specific combinations of inputs to use. Only if such information is available will it be possible to effectively improve the cost efficiency levels of smallholder farmers. What is clear at this stage is the fact that consciously selecting input combinations that will minimise costs requires substantial amounts of skills (i.e. human capital) from decision makers. Support structures should pay attention to transferring such skills to the farmers to allow them to benefit from improving their allocative efficiency levels. Farmers should also exploit their social capital levels (Jordaan and Grové, 2013) to learn from each other in terms of using least cost combinations of production inputs. Further research, however, is necessary to better understand the dynamics of the process through which the farmers make their decisions regarding input use.

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6. References

Coelli, T., Rahman, S., and Thirtle, C. 2002. Technical, Allocative Cost and Scale Efficiencies in Bangladesh Rice Production: A Non-Parametric Approach. *Journal of Agricultural Economics*, 53(3):607-626.

Jirgi, A.J. 2013. *Technical efficiency and risk preferences of cropping systems in Kebbi State, Nigeria*. PhD thesis. Department of Agricultural Economics, University of the Free State, Bloemfontein.

Jordaan, H., Grové, B., and Backeberg, G.R. 2014. Conceptual framework for value chain analysis for poverty alleviation. *Agrekon* 53(1):1-25.

Jordaan, H, Grové, B and Matthews, N. 2013. Investigating potential financial gains from using production inputs more efficiently. *Agrekon* 52(sup1):87-100.

Jordaan, H. and Grové, B. 2012. *An economic analysis of the contribution of water use to value chains in agriculture*. WRC Report No. K5/1779/1/12. Water Research Commission, South Africa.

McDonald, J. 2009. Using least squares and tobit in second stage DEA efficiency analysis. *European Journal of Operational Research*, 197:792-798.

Mooney, C.Z. and Duval, R.D. 1993. *Bootstrapping: A nonparametric approach to statistical inference*. SAGE Publications Inc., California.

National Planning Commission (NPC). 2011. *National Development Plan: Vision for 2030*. Available online at:

http://www.npconline.co.za/medialib/downloads/home/NPC%20National%20Development%20Plan%20Vision%202030%20-lo-res.pdf [Accessed on 15 June 2012]

Okoye, B.C., Onyenweaku, C.E., and Asumugha, G.N. 2006. Allocative Efficiency of Small- Holder Cocoyam Farmers in Anambra State, Nigeria. *Agricultural Journal*, 4(38): 70-81. Republic of South Africa (RSA). 2009. *Government's programme of action 2009.* Available online at http://www.gcis.gov.za/resource_centre/multimedia/posters_and_brochures/brochures/ poa2009.pdf [Accessed 3 March 2012].

Speelman, S., D'Haese, M., Buysse, J., and D'Haese, L. 2008. A measure for the efficiency of water use and its determinants, a case study of small-scale irrigation schemes in North- West Province, South Africa. *Agricultural Systems*, 98(1): 31-39.

Van Averbeke,W., Denison,J., and Mnkeni, P.N.S. 2011. Smallholder irrigation schemes in South Africa: A review of knowledge generated by the Water Research Commission. *Water SA.* 37(5):797-808.

Van der Merwe, E. 2012. *Economic literacy as a factor affecting allocative efficiency*. M.Sc. Agric thesis, Department of Agricultural Economics, University of the Free State, Bloemfontein.

Water Research Commission (WRC). 2008. *Knowledge review*, Water Research Commission, South Africa.